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The Soils of Tennessee: Their Chemical Composition and Fertilizer Requirements

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Charles A. Mooers

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THE SOILS OF TENNESSEE

THEIR CHEMICAL COMPOSITION AND FERTILIZER REQUIREMENTS

(SECOND EDITION)

BY

CHARLES A. MOOERS

KNOXVILLE, TENNESSEE

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OF THE UNIVERSITY OF TENNESSEE

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PREFACE

For a number of years the soils of Tennessee have been considered an important subject of investigation by the Station. But the State is large, covering over 42,000 square miles, and the soil types are numerous, so that with the limited funds available for this purpose the task is far from completion. In this bulletin, however, are presented the chemical ananyses and other data which have been obtained since the publication of the former soil bulletin, No. 3, Vol. X, by C. F. Vanderford, and also such conclusions are drawn and recommendations made as the results appear to warrant.

The maps published with the first bulletin are valuable for reference in connection with this one, but should be considered as giving only a general idea of the locations of the different type soils. For accurate maps reference can be made to the folios of the U. S. Geological Survey.* Unfortunately, however, only a part of the State— nearly all of East Tennessee and a portion of Middle Tennessee— has been thus surveyed.

The nomenclature for the various formations mentioned here is the same as that of the folios, but differs in the following instances from that of Bulletin No. 3, Vol. X:

Names used in former bulletin	Names used in this bulletin
Lenoir limestone	Chickamauga limestone
St. Louis or coral limestone	Bangor and Newman limestones
The Barrens	Tullahoma formation, Ft. Payne chert, etc.
Iron limestone	Tellico sandstone
Knox shale	Nolichucky shale

The methods of analysis followed are essentially those of the American Association of Official Agricultural Chemists. A few exceptions, however, were made. For potash the direct determination, according to the method of Moore,* was used. Particular attention was given to the accurate determination of phosphoric acid, and after a thorough investigation on artificial soil solutions, a modification of the Pemberton volumetric method was selected as giving the best results.

*Jour. Am. Chem. Soc., 1898, 20, p. 342.

The Official method for humus when strictly followed was found to be unreliable on account of the clay suspended in the ammonia solution. Fortunately a simple way to get rid of the clay was discovered, so that the results are free from what would otherwise have been a serious error.*

Special credit is due Mr. W. E. Grainger and Mr. H. H. Hampton, both of this Station, for valuable assistance in the analytical work. Mr. Hampton, in addition to making some of the analyses throughout, made all the humus determinations and also duplications of a large number of the phosphoric acid determinations. Mr. Grainger's work included practically all of the West Tennessee soils and all the analyses of insoluble residues in Table XXII.

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*The modification as devised by Mr. Hampton is as follows:

The Official method is followed up to the point where the ammoniacal solution of humus is ready for filtering. About 450 c.c. of this solution is drawn off into a 500 c.c. flask and allowed to stand for about forty-eight hours. This gets rid of a large part of the clay, which settles out much faster than when in cylinders. 100 c.c. is then siphoned off into a 250 c.c breaker and evaporated to dryness on the water bath, and the residue is allowed to bake on the water bath for a couple of hours. The humus is then dissolved out with 4 per cent ammonia and filtered off through ordinary filter paper, when most of the clay remains behind in a flocculated condition. The process is repeated and the second filtrate will generally be found free from clay; if any should be present, a third evaporation, etc., is resorted to.

A slight danger of loss of humus is encountered in the first evaporation, and should the residue of clay have any appearance of holding humus matter it is boiled with 4 per cent ammonia and carried down on a water bath as before, baked, taken up with 4 per cent ammonia, filtered, and the filtrate added to the main solution.

The clear humus solution is finally transferred to a tared platinum dish and the determination completed as usual.

THE SOILS OF TENNESSEE

THEIR CHEMICAL COMPOSITION AND FERTILIZER REQUIREMENTS

A BRIEF GENERAL SURVEY

In passing from the eastern to the western limits of the State marked variations both in the soils and in the farming conditions are readily noticeable. In East Tennessee sharp contrasts occur. The prevailing soils range in color from light grey to dark red, and in texture from sandy loam to clay loam. Many of the valleys have the appearance of being fertile and well farmed; others are poor and abandoned. Some of the hill lands are highly productive, and that others are of the opposite character is evident at a glance. On the Cumberland Plateau is found a large area which although supporting a fair forest growth has little durability under farm cropping. On descending from the Plateau there are found extending around the Central Basin of Middle Tennessee, and forming the outer part of the Highland Rim, fertile, red-colored soils of limestone origin. Next to them, and forming the inside of the Rim, are the poor grey and yellow-colored soils of the Barrens. A marked change again takes place, however, when the Rim has been crossed and the rich limestone area of the Central Basin is entered. On every hand are indications of greatly increased soil fertility. There are better farm buildings and better-kept farms, with extensive fields, which, even after 75 years of cultivation with the return of little of the plant food removed, produce superior crops of grain and grass. In West Tennessee the farming conditions are distinctly different from those of the other sections. The soils are by nature fairly fertile and durable, and are remarkable for the great variety of crops which they produce to advantage, but have suffered much from one-sided cropping and from erosion. On the western boundary, along the Mississippi River, are alluvial soils of almost unsurpassed fertility. It is especially noteworthy that throughout the State each change in soil type coincides to a marked extent with a change in the rock or other geological formation from which the soil originated.

PRIMAL CAUSES OF VARIATION IN FERTILITY

What are the fundamental causes of these differences in fertility? Why, for instance, should not the limestone rock of East Tennessee and of the Highland Rim produce lands equally as fertile and durable as does the limestone of the Central Basin? Why does the decay of the sandstones of the Cumberland Plateau not produce equally as strong and durable soils as the decay of the Tellico sandstone of the East Tennessee Valley? Why is it that in a single county, like Giles, there can be found some of the richest and most durable soils in the State and others which would be classed with the poorest?

The investigation of the fertile and durable lands found in this State discloses, so far as the writer is able to judge, little uniformity in physical composition; that is, there are both rich and poor loams, silt loams, clay loams, etc. In fact, there is only one apparent feature in which the soils of similar productiveness under continued cropping closely resemble each other, and that is their contents of the mineral elements of plant food, phosphoric acid in particular. However, without a certain abundance of each of these elements no soil has been found which has proved to be both rich and durable under cultivation. The key to the situation so far as Tennessee soils are concerned seems to be this, that they originated from different formations, which were very unequally supplied with the mineral plant-food elements, and the resulting soils have the same characteristics. Given the phosphoric acid, the lime, the potash, etc., the nitrogen supply can be accounted for through the action of nitrogen-gathering bacteria, but along with the humus, soil nitrogen is much influenced by conditions which do not affect the mineral elements.

CHEMICAL SOIL ANALYSES

Chemical analyses of soils may, as a rule, be placed in three classes, as follows:

I. The analysis which gives the total soil contents of the various elements.

This analysis is made chiefly in order to determine the total possible supplies of plant food. A high content of phosphoric acid, for example, would certainly tend toward durability with respect to that element. On the other hand, a great deficiency would indicate at once that little could be derived from the soil and that additions from outside sources would be imperative. For examples of such analyses from various formations, see Table XXI.

II. The usual analysis, the chief object of which is the estimation of the total available plant food.

This analysis is of particular value in the determination of the status of a soil with regard to productiveness and durability under continued cropping. The majority of the analyses in this bulletin belong to this class and are given in full in Table XXV.

III. Analysis made with the object of determining the supplies of the immediately available mineral elements of plant food.

Such an analysis may give a valuable indication of the plant-food status of the soil so far as the next crop is concerned, and in extreme cases would also show the presence of immediately available supplies sufficient for a number of years. In the writer's opinion the most important place for this analysis is as a supplement to the usual analysis (class II). The soils on every farm can not at present be analyzed once in a lifetime, to say nothing of once a year. Those of similar origin and character should therefore be grouped and the extent of their available plant-food supplies be determined first of all. In many instances, as may be seen in the tables here published, these supplies are at most meager, and nothing further is required to demonstrate the advisability, not only of supplying certain elements for the immediate crop, but also of continuing to do so under any kind of farming.

THE PRINCIPAL OBJECTS OF THE PRESENT INVESTIGATION

As practically all of the upland soils of this State are of residual origin—formed where they lie, as the result of the decomposition of the rock or other material similar to that which underlies them—one of the prime objects of this investigation was to determine for each type the range of variation of the important plant-food elements. That each formation has given rise to soils of at least fairly well-defined physical characteristics, such as color and texture, is evident to those familiar with them, and suggests similarity in mineral constituents. The completion of such a task requires the analysis of soils from numerous localities, which has not been attained for certain types. The results gotten, however, indicate that soils in widely separated places, but of the same geological origin, have marked similarities with respect to their contents of the mineral elements of plant food.

A further object was to determine the extent of the available plant-food supplies. In the determination of the total amounts of the various mineral elements there are included those portions in the interior of the grains of sand and silt which are far beyond the reach of plant roots as well as those which are readily accessible. Numerous methods, therefore, have been advocated for the estimation, not of the total but the *total available* amounts. The results here given, as obtained by the Official methods of analysis, according to which the soil is extracted for ten hours, at the temperature of boiling water, with strong hydrochloric acid (Sp. Gr. 1.115), are considered to represent the only supplies from which plants can draw for many years.

THE INTERPRETATION OF THE USUAL ANALYSIS

Agricultural chemists are generally agreed that the making of fine distinctions from chemical soil analyses of this class is not warranted, but that, on the other hand, marked instances either of the abundance or of the deficiency of an important element are of much practical value. Hilgard, the oldest and most distinguished soil chemist and physicist of this country, makes the following statements in his recent work on soils: "Virgin soils showing high percentages of plant food as ascertained by extraction with strong acids (such as hydrochloric, nitric, etc.) invariably prove highly productive; provided only that extreme physical characters do not interfere with normal plant growth, as is the case with heavy clay or very coarse sandy lands. To this rule no exception has been found."* He also calls attention to the facts that the "ascertainment of the *permanent productive* value of soils, as against that of their immediate capacity," is the object

*Soils (1906), p. 343.

in view, and that the failure to make this distinction has been the cause of much misunderstanding. Even a soil very poor in plant food, after being thrown out of cultivation for a few years may accumulate enough readily available supplies to produce at least one good crop. Such a condition this analysis would not indicate, but it should, on the other hand, show the lack of durability under cropping.

After long investigation, much of which was on soils in the South, Hilgard* draws the following conclusions in regard to the interpretation of a chemical analysis as made by his method, with the provision, however, that the soil be not deficient in lime, at least to the extent of acidity, in which case the limits should be raised:

Phosphoric acid—"All soils showing percentages between 0.10 and 0.05 per cent are considered weak on this side and are liable to need phosphate fertilization soon." 0.25 per cent is "unusually high" and 0.30 per cent or over "exceptional."

Potash—A smaller amount than 0.25 per cent is likely to call for potash fertilization, while as much as 0.45 per cent causes land to respond but feebly to this element. These figures apply to soils under both humid and arid conditions.

Nitrogen—0.10 per cent of nitrogen means "ordinary adequacy."

Lime—There should be present not less than 0.10 per cent in sandy lands, or 0.60 per cent in heavy clays. 0.20 per cent in sandy soils and 1.00 per cent in clays are desirable.

A large amount of work has been done on this subject by European agricultural chemists, and there is among prominent investigators in various countries a substantial agreement as to the plant-food contents of soils which are naturally "rich," "good," "poor," etc. The following table gives the limits set by F. Wohltmann† from an investigation of soils in Germany, and is selected as representative of the opinions held:

TABLE I—*A classification of soils based on chemical composition according to Wohltmann*

Character of soil	Constituents in air-dry fine earth (less than 2 mm.)				
	Nitrogen (N)	Lime (CaO) and Magnesia (MgO) (Cold HCl)	Phos. acid (P_2O_5) (Cold HCl)	Potash (K_2O) (Cold HCl)	Potash (K_2O) (Hot HCl)
	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
Very rich—may be cultivated without return of fertility removed	Over 0.3	Over 3.0	Over 0.25	Over 0.2	Over 0.5
Rich—requires partial return of Phos. acid removed	0.2–0.3	1.5 –3.0	.15–.25	.15–.2	.4–.5
Good — requires return of Phos. acid removed	.1– .2	.5 –1.5	.10– 15	.10–.15	.2–.4
Medium—requires return of Phos. acid and potash removed	.06– .1	.25– .5	.07–.1	.06–.1	.12–.2
Poor — requires general increase in fertility	.03– .06	.1 – .25	.04–.07	.03–.06	.08–.12
Very poor—very much in need of increase in fertility or periodical rest	.02– .03	.05– .10	.02–.04	.02–.03	.05–.08
Of little value for cultivation—best suited to meadows and pastures	<.02	<.05	<.02	<.02	<.05

*Soils (1906), p. 353 et seq.
†E. S. R., Vol. XIII, pp. 533, 534.

It should be noted that Wohltmann used a stronger acid solution than that required by our Official methods, but that the digestion was in cold acid, except for potash, in which case a digestion was also made in hot acid. The method used by Hilgard makes a more thorough extraction of the soil than either of the others, the strength of the acid being the same as in the Official method, but the time of digestion being longer.

It is highly probable that the amounts of lime, magnesia and phosphoric acid obtained by each of the three methods would be reasonably comparable. The Official method would, however, be expected to extract less potash than the Hilgard method, but more than Wohltmann's, while the total nitrogen should be the same whatever the method used.

Based on the results published in this and the former bulletin, together with what has been learned in regard to the productiveness of these soils under cropping, and their present needs as brought out in fertilizer trials, the writer has prepared a tentative table (III) for use in the interpretation of these analyses. The words "very poor," "poor," etc , in the conclusions from analyses which follow the analytical results are with reference to these limits. But in the remarks which follow each analysis the words "very poor," "poor," etc., have reference to the present productiveness of the soil under common conditions of tillage, without applications of commercial fertilizers or more than very light dressings of manure. Any such scheme is of course imperfect, for one farmer often excells another in skill and judgment. Whether or not a good rotation including the successful growing of clover be practiced, would have a most marked effect on the yields obtained.

TABLE II—*A classification of Tennessee soils based on productiveness.*

1	Very poor	Less than 15 bu. corn or " " 6 " wheat
2	Poor	15-25 " corn or 6-10 " wheat
3	Medium	25-35 " corn or 10-18 " wheat
4	Good	35-40 " corn or 18-25 " wheat
5	Rich	Over 50 " corn or " 25 " wheat

THE SOIL SAMPLES

The samples for analysis were nearly all taken from soils belonging to one of two distinct classes: (1) virgin soils, either from the forest or from newly cleared land, and (2) old lands, which, like the majority of those under cultivation in the State, had not been modified by previous manuring or fertilizing. In only a few instances was this rule broken, and attention is called to them in the tables of analyses. An effort was always made to get a fair average by taking samples at numerous places in the fields and by avoiding both very rich and very poor spots. Uplands which had either suffered much from erosion or been appreciably modified by the washings from higher levels were also avoided, so that as far as possible samples were obtained which represented the soil under what might be called normal conditions.

The usual depth to which a sample was taken was six inches, but if the line between the soil and subsoil was evidently deeper, as is usual for the bottom lands, the sample was taken accordingly. The subsoil samples were as a rule taken at a point distinctly below the line between soil and subsoil. On the poorer lands they represent the second six inches, but on the more fertile soils they were often taken below a depth of nine inches.

The samples thus obtained were air-dried and sieved, only the fine earth which would pass through round holes ½ mm. (about 1-50 of an inch) in diameter, being used in the analysis.

TABLE III—*Interpretation of the analyses*

	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)
	P. ct.	P ct.	P. ct.	P. ct.
1 Very poor	Less than 0.05	Less than 0.08	Less than 0.10	Less than 0.07
2 Poor	0.05-0.10	0.08-0.12	0.10-0.15	0.07-0.10
3 Medium	0.10-0.15	0.12-0.20	0.15-0.25	0.10-0.14
4 Good	0.15-0.25	0.20-0.40	0.25-0.40	0 14-0.20
5 Rich	Over 0.25	Over 0.40	Over 0.40	Over 0.20

THE EAST TENNESSEE VALLEY

This section, which lies between the Unaka or Great Smoky Mountains on the east and the Cumberland Plateau on the west, has an area of about 9,200 square miles and an average elevation of about 1,000 feet. The geological formations, including ridges, etc., have northeast and southwest courses, parallel with the mountains on either side, and occur repeatedly in long belts or strips.

The most important soils of this section may be placed under the following heads:

1 Knox dolomite
2 Shale
3 Chickamauga limestone
4 Miscellaneous marbles and limestones
5 Tellico sandstone
6 Alluvial

THE KNOX DOLOMITE FORMATION

Three samples of dolomite rock, taken from different localities and analyzed by the writer, gave, in round numbers, from 28 to 29½ per cent of lime, from 20 to 21½ per cent of magnesia, and from 3½ to 9 per cent of residue insoluble in strong hydrochloric acid. The average composition of the formation is, however, impossible of determination on account of the presence of irregular layers and nodules of chert, which is nearly pure silica, so that the dissolving away of the lime and magnesia left behind not only the finely subdivided insoluble residue, but also the coarse chert, which appears in the soil as gravel and "hard heads."

This formation covers not less than one-third of the East Tennessee Valley. Large areas are found (1) south of Jacksboro, and extending southwest to Walden's Ridge and northeast to the state boundary; (2) in the vicinity of Morristown, New Market and Jefferson City, and extending southwest to Thorngrove; (3)from Dandridge to Whitepine; (4) from Maryville to near Madisonville; (5) west of Concord, Loudon, Philadelphia, Athens, and Calhoun, Bluespring and beyond; (6) around Benton; (7) around Unitia, Coytie and Piney; (8) around Hiwassee College, Morganton and Cloyd's Creek; (9) from Hiwassee River northwest, connecting with Copper Ridge; (10) making up the major part of Tuckaleechee and Cades Coves; (11) forming the central part of the Sequatchie Valley from Cold Spring southwest through Pikeville; (12) in the southeastern half of Greene and the northwestern half of Washington County; (13) from Chattanooga, extending northeast to Rockwood, and lying for a number of miles on both sides of the Tennessee River, to a point a little above Hiwassee Island.

The most prominent ridges belonging to this formation are as follows:

Black Oak
Caney
Chestnut
Copper
Crockett
Dividing
McMinn
Spring Creek

THE DOLOMITE SOILS

The prevailing soils are loams and silt loams containing more or less "chert," or angular siliceous fragments of all sizes up to those of several pounds weight. The color of the soils ranges from gray to dark red. All have retentive red clay subsoils. Valley lands of this type are considered to be of good natural fertility, and under judicious management are highly productive, but under continued grain growing they soon become impoverished. The soils of the rounded ridges which characterize this formation contain as a rule much more chert and are recognized as naturally much poorer and less durable than the valley lands.

The valley lands are well adapted to general farm crops, such as corn, wheat, grass, etc., but when favorably located are used for market-garden and fruit-growing purposes. The ridges are adapted to the production of small fruits, grapes, and general orcharding, peaches and cherries in particular. The most important practical question in regard to these soils is, what should be done to increase their fertility and durability; for at this time there are in the aggregate large areas which are cropped with profit only once in two or three, or even more, years, and other large areas, especially on the ridges, which have been thrown entirely out of cultivation.

TABLE IV—*Chemical analyses of Knox dolomite soils—ridge type*

Lab. No.	County	Locality	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
58	Hamblen	River Ridge..........	0.04	0.08	0.12	0.112	Forest land—poor
59	"	" "	0.03	0.06	0.07	0.037	Subsoil to No. 58
55	"	Hodge's Hill.........	0.04	0.10	0.10	0.109	Old land—very poor
606	Knox....	About 3 miles N. E. of Knoxville.........	0.04	0.12	0.09	0.135	Forest land
31	"	Black Oak Ridge.....	0.03	0.09	0.14	0.079	Old land—very poor
102	"	" " "	0.02	0.06	0.21	0.044	Subsoil to No. 31
48	"	" " "	0.05	0.14	0.16	0.101	Old land—medium

TABLE V—*Chemical analyses of Knox dolomite soils—valley type*

Lab. No.	County	Farm of	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
64	Hamblen	F. W. Taylor, Morristown...............	0.05	0.16	0.23	0.095	Old land—medium
25	Knox....	Experiment Station...	0.09	0.17	0.28	0.111	" " —good
172	McMinn.	J. B. Stinespring, Sanford............	0.06	0.13	0.38	0.079	" " —poor
173	"	J. B. Stinespring, Sanford................	0.05	0.12	0.43	0.051	Subsoil to No. 172

GENERAL CONCLUSIONS FROM ANALYSES

RIDGE TYPE

Phosphoric acid—The phosphoric acid contents of these soils must be considered as very poor, so that the application of available phosphoric acid would be expected not only to give good results, but to be a necessity in the efficient building up of the soil and in its maintenance. The agreement in the results is noteworthy. especially as the samples were taken from widely separated localities.

Lime—The lime contents are poor, indicating the need of increased supplies.

Potash—The supplies of potash must be looked upon as poor, so that at least the moderate use of potash salts is advisable.

Nitrogen—The nitrogen contents of the virgin soils are medium, but the worn soils tend to be poor, requiring serious attention.

VALLEY TYPE

The analyses of the valley soils show larger amounts of all the mineral elements of plant food, potash and lime in particular, than the ridge type. The phosphoric acid contents, however, are poor, and may account for the lack of durability under grain farming. The supplies of lime are medium. The percentages of potash are good, probably ample under stock farming, but would not endure the constant drain of grain and hay farming.

In three out of four soils the nitrogen contents are poor, and along with phosphoric acid should receive much attention.

FERTILIZER EXPERIMENTS

The following table gives the results of fertilizer experiments on a long-cultivated ridge soil:

TABLE VI—*Fertilizer experiments on dolomite ridge soil; results, etc., per acre*

Plot	Fertilizer per acre	Yield	
		Hay	Grain
	COWPEAS	lbs.	bu.
1	500 lbs. acid phosphate (14%)	2037	9.2
2	500 lbs. acid phosphate 200 " muriate of potash	2570	8.6
3	No fertilizer	1051	4.8
	IRISH POTATOES		Tubers
1	500 lbs. acid phosphate 400 " cotton-seed meal 180 " muriate of potash	....	104.8
2	500 " acid phosphate 400 " cotton-seed meal	....	90.8
3	180 " muriate of potash 400 " cotton-seed meal	....	27.1
4	No fertilizer	....	15.0

Other fertilizer experiments have uniformly agreed with these in demonstrating the great need of both phosphoric acid and nitrogen by this type. Potash along with the phosphoric acid has practically always increased the yields of hay and potatoes, but has not as a rule affected the production of grain. Such a deficiency under increased production from the use of phosphoric acid, etc., would, however, be expected soon to affect the yield of grain.

SHALE

Next to the Knox dolomite, shale from various formations covers the largest area in the East Tennessee Valley. No quantitative chemical analyses have been made of any of them, but the majority agree in being easily decomposed and in containing a large amount of silt and clay bound together principally by carbonate of lime.

The soils are often shallow, and have the general reputation of being leachy and troublesome to handle, due in large part to their high content of silt. This type occurs frequently as low lands, which, when of sufficient depth, are well suited to the production of both grain and grass. Very poor silt soils, known as "crawfishy," often arise from the disintegration of shale.

TABLE VII—*Chemical analyses of shale soils*

Lab. No.	County	Locality	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
60	Hamblen	Near Jarnagin .... (Nolichucky shale)	0.11	0.05	0.28	0.208	Old land—good
66	"	On Nolichucky River. (Athens shale)	0.02	0.10	0.08	0.072	" " "crawfishy" —very poor
32	Knox	Near Inskip	0.09	0.11	0.29	0.090	" " —poor
602	"	Near Knoxville .... (Sevier shale)	0.09	0.12	0.27	0.100	New land—medium
608	"	Near Knoxville .... (Sevier shale)	0.03	0.08	0.09	....	Forest, "crawfishy" —very poor

GENERAL CONCLUSIONS FROM ANALYSES

Phosphoric acid—The phosphoric acid supplies are nearly medium, except for the "crawfishy" sorts, which are very deficient. The best of these soils would be expected to require at least the return of this element removed by the crops.

Lime—The lime contents must be considered poor. In particular liming would be required in order to bring soil No. 60 to a high state of productiveness.

Potash—Except in Nos. 66 and 608, the potash percentages are good, but not sufficient to warrant the constant removal of this element without any return, as in grain or hay farming.

Nitrogen—No. 60 is rich in nitrogen, but the others would be considered poor.

FERTILIZER EXPERIMENTS

Fertilizer experiments made on soils long under cultivation have indicated a decided need of both phosphoric acid and nitrogen.

CHICKAMAUGA LIMESTONE

A sample of Chickamauga limestone taken from a railroad cut near Knoxville analyzed as follows:

	P. ct.
Insoluble residue	17.64
Lime (CaO)	40.90
Magnesia (MgO)	3.53
Ferric oxide (Fe_2O_3)	0.50
Alumina (Al_2O_3)	0.86
Carbonaceous matter and combined water	0.78
Carbon dioxide (CO_2) calc.	35.95
	100.16

As this formation exhibits much uniformity in general appearance the analysis is supposed to be representative.

The formation covers probably less than 1-12 of the East Tennessee Valley, and is found in narrow belts. The rock is easily recognized on account of its blue color, and its structure, which is of such a nature that it is often spoken of as rotten limestone. The high content of insoluble matter renders it unfit for burning.

The soils are high in both silt and clay, so that care in working is required to prevent the formation of clods. The subsoils are heavy yellow-colored clays. General farm crops, especially wheat and grass, thrive on this type.

TABLE VIII—*Chemical analyses of Chickamauga limestone soils of East Tennessee*

Lab. No.	County	Farm of	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
51	Hamblen	J. W. Wood, Morristown	0.10	0.82	0.86	0.308	Forest land—very rich
57	"	C. B. Williams, Morristown	0.07	0.18	0.37	0.097	Old land—poor
29	Knox	W. P. Ford, South Knoxville	0.08	0.22	0.43	0.120	Creek bottom land—good
821	"	W. P. Ford, South Knoxville	0.09	0.10	0.27	0.094	Old land—poor
174	McMinn	S. F. Gettys, Sanford	0.07	0.31	0.68	0.183	Fertile pasture
595	Roane	J. W. Ayres, Harriman	0.07	0.06	0.18	0.087	Old land—poor
597	Washington	Chas. A. Bowman, Boone's Creek	0.07	0.10	0.18	0.100	" " "

GENERAL CONCLUSIONS FROM THE ANALYSES

Phosphoric acid—The phosphoric acid contents of these soils are poor, requiring at least the return of the phosphoric acid removed by the crops. The uniformity in the percentages of this element in soils from different localities is noteworthy.

Lime—The percentages of lime are variable to an unusual extent. The virgin soils are well supplied, but those which have been long cultivated are often deficient, so that liming would be advisable.

Potash—In no instance is the potash content poor. Nos. 29, 51 and 174 are rich; No. 821 is good; and Nos. 595 and 597 are medium.

Nitrogen—The nitrogen contents of the long-cultivated soils are a low medium, but at least one of the virgin soils, No. 51, would be considered very rich in this element.

FERTILIZER EXPERIMENTS

The following table gives results of fertilizer experiments on a typical soil, which had been under cultivation for many years, but was in excellent mechanical condition, on the farm of W. P. Ford, South Knoxville.The chemical analysis of this soil is given in Table VIII, No. 821:

TABLE IX—*Fertilizer experiments on Chickamauga limestone*

No.	Fertilizer per acre	Yield per acre		
		Hay	Stover	Grain
		tons	tons	bu.
	COWPEAS			
1	200 lbs. acid phosphate	2.17	....	....
2	No fertilizer	1.55	....	....
3	200 lbs. acid phosphate 25 " muriate of potash	2.22	....	....
	CORN			
4	No fertilizer	....	0.83	22.3
5	6 tons manure	....	1.44	52.9
6	6 " manure 200 lbs. acid phosphate	....	1.62	59.1
7	200 lbs. acid phosphate 25 " muriate of potash	....	1.02	35.5

In these experiments, as in numerous others on this soil, increased yields resulted from the application of both phosphoric acid and nitrogen. Lime, whether used alone or in combination with the other two, also greatly increased the yield, not only of legumes, but also of wheat, the increase of the latter being due apparently to an increased supply of available nitrogen.

CONCLUSIONS FOR CHICKAMAUGA LIMESTONE SOILS OF EAST TENNESSEE

As a class these soils must be looked upon as only moderately well supplied with phosphoric acid so that applications of this element are recommended especially in grain farming. The long-cultivated soils need in addition both nitrogen and lime. Liming is advised not only on account of its value as plant food, but especially as a corrective for acidity and for its favorable action on those soils which are heavy and troublesome to handle. Little attention appears to be required for potash fertilization.

MARBLE AND MISCELLANEOUS LIMESTONES

The following is the analysis of a sample of Holston marble taken from a quarry in the vicinity of Knoxville:

	P. ct.
Insoluble residue	0.07
Lime (CaO)	55.12
Magnesia (MgO)	0.51
Ferric oxide (Fe_2O_3)	0.21
Carbon dioxide (CO_2) calc.	43.98
	99.89

On account of its purity the marble of East Tennessee is an important source of quicklime for building and agricultural purposes. Some of the hard, compact limestones from other formations, however, are occasionally used.

All these limestones form red or chocolate-colored loams and clay loams, which are recognized as naturally very fertile and much more durable under cropping than the dolomite and shale soils. They are especially well adapted to general farm crops, but may be used to advantage for gardening, orcharding and the like. Their area is small. The Holston marble, for example, covers about one per cent of the East Tennessee Valley.

TABLE X—*Chemical analyses of marble and miscellaneous limestone soils*

Lab. No.	County	Locality	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
129	Anderson	"Eagle Bend" Farm, Clinton	0.17	0.12	0.21	0.123	Old land—good
49	Hamblen	"Whiteside" Farm, near Turley's Ferry (Maryville limestone)	0.08	0.12	0.24	0.079	" " —poor
600	Knox	South Knoxville (marble in Sevier shale)	0.16	0.30	0.36	0.143	New land—rich
603	"	South Knoxville (marble in Sevier shale)	0.19	0.38	0.42	0.190	" " "
30	"	Near Inskip (Holston marble)	0.10	0.20	0.34	0.100	Old land—medium

GENERAL CONCLUSIONS FROM THE ANALYSES

Phosphoric acid—In three out of five soils the percentages of phosphoric acid are good. In fact, they are the highest found in any of the East Tennessee types. In strictly grain farming, however, the phosphoric acid removed by the crops should be returned, especially for Nos. 30 and 49.

Lime—The lime contents are better than the average, running from medium to good, but beneficial results would be expected to follow its application to Nos. 129 and 49.

Potash—The supplies of potash are good in three out of the five soils, but analyses Nos. 129 and 49 show only medium amounts of this element.

Nitrogen—The nitrogen supplies of the new lands are good, but the long-cultivated soils have been heavy losers of this element.

FERTILIZER EXPERIMENTS

The fertilizer experiments which have been made on these soils have shown that they do not respond readily to phosphoric acid like the other types described, but indicate that attention should be given to this element in grain farming. Nitrogen has been found to be needed after a few years of cropping in corn and wheat, as is the custom.

TELLICO SANDSTONE

A chemical analysis* of a typical sample of Tellico sandstone rock taken from a quarry near Knoxville is as follows:

*Analysis by C. O. Hill.

	P. ct.
Insoluble residue	38.87
Lime (CaO)	28.59
Magnesia (MgO)	2.98
Ferric oxide (Fe_2O_3)	2.06
Ferrous oxide (FeO)	0.96
Alumina (Al_2O_3)	.05
Carbon dioxide (CO_2) calc.	26.34
	99.85

The rock consists largely of sand cemented together by carbonate of lime. The area covered by this formation is small, but long, narrow strips are found scattered throughout the East Tennessee Valley.

The soils are especially desirable for market garden purposes, being sandy loams of good natural fertility. On account of the hardness of the parent rock they are found on the slopes and tops of high hills and sometimes on small elevated plateaus which are excellently situated for the production of early vegetables. On hillsides these soils wash ruinously, with rapid deterioration in fertility unless wisely handled.

TABLE XI—*Chemical analyses of Tellico sandstone soils*

Lab. No.	County	Farm of	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
37	Knox	Joseph Ford, South Knoxville	0.17	0.19	0.18	0.106	New land—good
553	"	Experiment Station (Fruit Farm)	0.11	0.16	0.18	0.120	Old land—good
593	Roane	J. W. Ayres, Harriman	0.10	0.26	0.30	0.152	New land—rich

GENERAL CONCLUSIONS FROM THE ANALYSES

Taking the texture into consideration, the percentages of all the elements of plant food are good and justify the reputation of these soils for being "naturally fertile."

FERTILIZER EXPERIMENTS

The following table gives the results of some cooperative experiments with C. M. Ford, South Knoxville:

TABLE XII—*Fertilizer experiments on Tellico sandstone soil*

Plot	Fertilizer per acre	Yield per acre
	SWEET POTATOES	bu.
1	No fertilizer	126
2	300 lbs. acid phosphate 100 " muriate of potash 360 " cotton-seed meal	230
3	300 " acid phosphate 360 " cotton-seed meal	218
4	300 " acid phosphate 100 " muriate of potash	170

CONCLUSIONS FOR TELLICO SANDSTONE SOILS

For market garden crops the old lands need especially both phosphoric acid and nitrogen and to a less extent potash.

ALLUVIAL SOILS

The alluvial soils of East Tennessee do not cover large areas, but are noted for their fertility and durability under cropping. They are best adapted to corn, grass, and forage crops, and are decidedly the most productive soils in the East Tennessee Valley. Their superior depth adds greatly to the plant-food supplies indicated in the chemical analyses.

TABLE XIII—*Chemical analyses of alluvial soils of East Tennessee*

Lab. No.	County	Farm of	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
35	Blount...	McBath, on Little River................	0.18	0.18	0.53	0.131	Old land--good (occasionally overflowed)
53	Hamblen	D. A. Jones, on Nolichucky River........	0.09	0.73	0.91	0.121	Old land -- medium (texture bad)
26	Knox....	Experiment Station, on Tennessee River.	0.12	0.43	0.45	0.145	Old land--rich (occasionally overflowed)
612	"	Experiment Station...	0.09	0.42	0.42	0.131	Old land--rich (rarely overflowed)
27	"	———, Sandy island, in Tennessee River.....	0.05	0.41	0.32	0.073	Old land--rich (overflowed yearly)

GENERAL CONCLUSIONS FROM THE ANALYSES

Phosphoric acid—The percentages of phosphoric acid run from poor in the sandy soil to good, but the depth and texture of these soils make them well supplied though not rich in this element.

Lime—With the exception of No. 35 these soils are rich in lime, at least so far as plant-food requirements are concerned.

Potash—They are also rich in potash.

Nitrogen—The nitrogen percentages are for the most part only medium, but, as in the case of phosphoric acid, the depth of the soil makes the supplies good.

FERTILIZER EXPERIMENTS

At the Experiment Station farm on soil No. 612 no profitable returns have been obtained from the use of fertilizer mixtures for either corn or wheat; the wheat generally growing too rank, so that it lodges. Alfalfa and clover, however, respond to applications of both phosphoric acid and lime, but the effects of the latter must be attributed to the slight acidity of the soil. Grass responds to nitrogen in addition to the other two elements.

CUMBERLAND PLATEAU

The Cumberland Plateau covers about 5,100 square miles and has an average elevation above sea level of about 1,800 feet, or nearly 1,000 feet above either the East Tennessee Valley or the Highland Rim of Middle Tennessee. The soils are principally sandy loams, which support a fair forest growth, but which are decidedly lacking in fertility under cropping. On account of their loamy nature they are easily tilled and are well suited to the production of trucking and forage crops and to both large and small fruits. The cultivated soils are shallow, the depth to the underlying sandstone generally ranging from 1 to 4 feet. They seldom suffer from dry weather, however, and there is no reason why under judicious management, which would include the liberal use of fertilizers and of lime, much of this section should not become highly productive.

TABLE XIV—*Chemical analyses of soils from the Cumberland Plateau*

Lab. No.	County	Farm of	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P ct.	P. ct.	P. ct.	P. ct.	
746	Cumberland ...	——, Crossville ..... (Walden sandstone)	0.06	0.07	0.19	0.161	Uncleared pasture—best type of Plateau soil—a sandy loam
605	" ...	A. E. Payne, Crossville	0.03	0.10	0.07	0.279	A creek bottom soil —very acid
67	" ...	R. W. Powell, Westel..	0.03	0.05	0.08	0.085	Forest land, average —very poor
68	" ...	" " "	0.03	0.05	0.06	0.069	Subsoil to NO. 67

GENERAL CONCLUSIONS FOR THE CUMBERLAND PLATEAU SOILS

These soils can be classed in plant-food supply with those of the Barrens, and must be considered as very poor in all mineral elements of plant food, so that it would not be advisable to attempt any kind of farming without the aid of commercial fertilizers furnishing both phosphoric acid and potash. Lime in addition is indicated as necessary not only for plant-food purposes but also to correct acidity. Some of the soils are rich in both nitrogen and humus, but the average soil is poor in these constituents.

Fertilizer experiments bear out the results of the chemical analyses in showing the great demand for increased supplies of phosphoric acid, nitrogen and lime, but potash seems to be of uncertain value.

THE HIGHLAND RIM

The "Highland Rim" is the name given to a portion of Middle Tennessee which surrounds in a wide circle the Central Basin something like the rim of a dinner plate. It covers about 9,300 square miles, and may be divided into two sections; (1) an outer circle formed by the Bangor and other limestones, and (2) an inner and wider circle formed by the Tullahoma formation, Fort Payne chert, etc., known as the Barrens.

THE LIMESTONE SOILS OF THE RIM

The Rim soils of limestone origin range in color from grey to dark red and have red clay subsoils. Silt and clay loams predominate and are well suited to the production of grain and forage crops. Some of the most successful nurseries in the State are located on the dark red soils near Winchester, and the region about Clarksville is a noted center for the production of dark-leaved tobacco. All of these soils are recognized as decidedly superior in both productiveness and durability to those of the Barrens.

TABLE XV—*Chemical analyses of limestone soils of the Highland Rim*

Lab. No.	County	Farm of	Phos. phoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
750	Coffee ...	F. A. Raht, Hickerson Station	0.07	0.23	0.23	0.115	Old land, color dark red—good
39	Franklin	J. Kaserman, Winchester	0.09	0.21	0.31	0.125	Old land, color dark red — good (much modified by manuring, etc.)
565	"	Richard Taylor, Winchester	0.10	0.16	0.27	0.120	Old land, color dark red—medium
566	"	Richard Taylor, Winchester	0.05	0.14	0.34	0.040	Subsoil to No. 565
592	Humphreys ...	——, near Waverly..	0.06	0.13	0.23	0.120	Old land, color red—poor
569	Lawrence	————————, near Lawrenceburg	0.08	0.08	0.16	0.100	Forest land, color red—medium
570	"	"	0.06	0.08	0.28	0.060	Subsoil to No. 569
742	Montgomery	Odd Fellows, Clarksville	0.06	0.15	0.22	0.074	Old land, color grey
581	Stewart..	J. H. Byers............	0.05	0.12	0.15	0.115	Forest land—good
583	"	" "	0.05	0.15	0.17	0.105	" " "
571	White ...	W. M. Williams, Sparta..............	0.06	0.14	0.20	0.085	Old land, "cragrock," color grey—medium
574	" ...	W. M. Williams, Sparta..............	0.07	0.13	0.22	0.080	Old land, "cragrock," color grey—medium
563	" ...	W. M. Williams, Sparta..............	0.07	0.09	0.21	0.090	Old land, sandy loam, color grey—poor
564	" ...	W. M. Williams, Sparta..............	0.05	0.14	0.32	0.057	Subsoil to No 563

GENERAL CONCLUSIONS FROM THE ANALYSES

Phosphoric acid—The phosphoric acid percentages are poor, so that applications of this element would undoubtedly be of value and should be considered necessary in at least some instances.

Lime—The lime content is as a rule only medium and indicates that liming would be profitable. The percentages of Nos. 569, 570 and 571 are poor.

Potash—The supply of potash is medium to good, requiring less attention than the other important elements of plant food.

Nitrogen—The supplies of nitrogen run from medium to poor and require attention.

FERTILIZER EXPERIMENTS, ETC.

Fertilizer experiments have shown the importance of both phosphoric acid and nitrogen. Through the keeping of live stock, and by judicious management, aided only by moderate dressings of bone meal, the soil from which No. 39 was obtained had in the course of a few years been brought up to a high state of fertility, although previously it had been greatly impoverished by grain farming and by erosion.

THE SILICEOUS SOILS OF THE RIM

These soils originated chiefly from the decomposition of shale and siliceous rock, which were poor in lime. They are generally either grey or yellow colored and are characterized by a high content of silt, the "crawfishy" soil being of common occurrence. The majority of the lands lie well for cultivation and are easily tilled, but are naturally poor. However, under proper management, aided by liming and by the liberal applications of commercial fertilizers, they are capable of the profitable production of a great variety of farm and garden crops. Peanuts are grown extensively in some counties and trucking crops and tobacco are being raised in others.

TABLE XVI—*Chemical analyses of soils from the Tullahoma formation, Fort Payne chert, etc.*

Lab. No.	County	Locality	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
867	Coffee ...	Tullahoma	0.04	0.15	0.09	0.077	Old land—very poor
591	Dickson .	Near Dickson	0.04	0.08	0.16	0.087	Forest land—poor
589	"	" "	0.03	0.10	0.10	0.090	Old land—very poor
590	" .	" "	0.03	0.02	0.31	0.048	Subsoil ¼ mile from No. 589
585	Houston .	R. H. Miller, Erin	0.04	0.10	0.15	0.090	Forest land on hill-top
586	"	" " "	0.03	0.05	0.12	0.040	Subsoil to No. 585
582	"	" " "	0.06	0.09	0.15	0.060	Old land—very poor
579	" .	" " "	0.09	0.34	0.13	0.070	Creek bottom land—good (modified by manuring, etc.)
587	Lewis ...	Near Hohenwald	0.03	0.06	0.18	0.050	Not cultivated—very poor
588	"	" "	0.04	0.03	0.25	0.040	Subsoil to No. 587
843	Putnam .	Cookeville	0.03	0.07	0.07	0.070	Old land—very poor
806	Warren . .	W. N. Rudd, McMinnville	0.04	0.10	0.14	0.078	Old land—poor
575	" . .	Chas. Weaver, McMinnville	0.02	0.07	0.08	0.070	Old land—very poor
580	" . .	Chas. Weaver, McMinnville	0.02	0.07	0.11	0.046	Subsoil to No. 575

GENERAL CONCLUSIONS FROM THE ANALYSES

Phosphoric acid—The phosphoric acid percentages are decidedly poor, indicating that applications of this element should be looked upon as a necessity in any kind of farming.

Lime—The lime poverty is very marked in some cases, indicating that liming would be required in addition to the phosphoric acid in order to get the best results.

Potash—The potash supplies are poor, so that at least the return of the potash removed by the crops would be required.

Nitrogen—The nitrogen contents are either poor or very poor in all cases.

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*This soil probably of limestone origin.

FERTILIZER EXPERIMENTS

In series 1 of Table XVII are given the results obtained by W. N. Rudd in field experiments on a very poor soil on his farm near McMinnville.

In series 2 are the results of experiments on the same farm but from another field which had been somewhat improved by previous fertilizing, etc. The analysis of this soil is given in Table XVI, No. 806.

TABLE XVII—*Fertilizer experiments on Fort Payne chert soil*

Plot	Fertilizer per acre	Yield per acre	
		Stover	Grain
		tons	bu.
	CORN		
1	No fertilizer	0 31	3 9
2	640 lbs. acid phosphate 128 " muriate of potash	0 61	18.3
3	640 " acid phosphate 240 " nitrate of soda	0.70	23.5
4	640 " acid phosphate 240 " nitrate of soda 128 " muriate of potash	0 91	24.9
5	240 " nitrate of soda 128 " muriate of potash	0.37	4 3
6	640 " acid phosphate 240 " nitrate of soda 256 " muriate of potash	1.01	29.3
	COWPEAS		
1	No fertilizer	....	13 0
2	300 lbs. acid phosphate	....	19.0
3	300 " acid phosphate 50 " muriate of potash	....	22.00

CONCLUSIONS FOR THE SILICEOUS SOILS OF THE RIM

The results of the chemical analyses and the fertilizer experiments agree in demonstrating that the soils of the Barrens are very poor in the fundamentally important mineral elements of plant food. Phosphoric acid and lime are indicated as the foremost essentials, the need of potash being of secondary importance. The nitrogen supplies are also low so that for cereal and other crops not legumes this element should be used along with the minerals.

CENTRAL BASIN

The Central Basin covers approximately 5,500 square miles, and has an average elevation above sea level of about 550 feet. Several limestones occur here, but their areas have not been mapped by the Geological Survey. Phosphate beds are found in numerous localities. The major part, however, of this section is covered by the Chickamauga limestone, which is locally known as "blue limestone." The soils as a whole are noted for their superior fertility and durability under cropping as compared with those from other parts of the State.

Continued cropping in corn and wheat has, however, greatly reduced the natural productiveness of the majority of the uplands, but the quickness with which they recover under proper management is almost remarkable. The bottom lands are exceptionally fertile. The uplands generally lie well for cultivation, but steep and isolated hills 200 to 300 feet high are not uncommon. They are, however, nearly always very fertile. Scattered throughout this Basin are "cedar glades," where the soil is not deep enough for cultivation but furnishes pasturage and is the natural habitat of the red cedar. The prevailing soils are brown-colored silt loams, adapted to a wide range of crops, but especially well suited to the production of corn, wheat, grass and forage crops. Potatoes are also grown extensively in some of the counties. Kentucky blue grass thrives as nowhere else in the State and is the common permanent pasture grass.

TABLE XVIII—*Chemical analyses of Central Basin soils*

Lab. No.	County	Farm of	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
751	Bedford	G. W. Clark, Wartrace	0.15	0.10	0.29	0.122	Old land—good
615	"	R. E. Ayres, Wartrace	0.09	0.28	0.17	0.112	Old land—good (bottom 2nd bench)
616	"	" " "	0.08	0.26	0.15	0.117	Old land—good (bottom, grey soil)
572	"	Robt. Gallagher, Shelbyville	0.12	0.24	0.33	0.130	Old land—good
573	"	Robt. Gallagher, Shelbyville	0.05	0.31	0.49	0.040	Subsoil to No. 572
577	"	Robt. Gallagher, Shelbyville	0.19	0.57	0.46	0.150	Creek bottom land—rich
578	"	Robt. Gallagher, Shelbyville	0.05	0.05	0.19	0.090	Old land—very poor
747	"	T. L. Huffman, Normandy	0.17	0.14	0.26	0.148	" " —good
748	"	T. L. Huffman, Normandy	0.11	0.11	0.31	0.068	Subsoil to No. 747
170	"	W. R. Webb, Bellbuckle	0.26	0.20	0.32	0.112	Old land—good
171	"	W. R. Webb, Bellbuckle	0.18	0.19	0.43	0.077	Subsoil to No. 170
175	"	W. R. Webb, Bellbuckle	0.15	0.57	0.43	0.212	Old meadow, bottom land—rich
176	"	W. R. Webb, Bellbuckle	0.15	0.61	0.43	0.212	Subsoil to No. 175
617	Davidson	Nat Baxter, Nashville	0.07	0.46	0.71	0.190	New land—rich
42	Lincoln	Conger Bros., Fayetteville	0.31	0.32	0.45	0.128	Old land—good
561	Marshall	J. R. Bryant, Mooresville	0.32	0.20	0.19	0.102	" " —medium
633	"	W. W. Ogilvie, Lewisburg	0.26	0.18	0.25	0.116	" " —good
660	"	W. W. Ogilvie, Lewisburg	0.27	0.27	0.33	0.065	Subsoil to No. 633
635	Rutherford	R. H. Kittrell, Murfreesboro	0.08	0.22	0.29	0.116	Old land—medium
822	Smith	——, Gordonsville	0.22	0.17	0.22	0.076	" " —poor
634	Sumner	R. P. Hite, Gallatin	0.21	0.23	0.24	0.107	" " —good
160	"	W. G. Schamberger, Gallatin	0.26	0.38	0.33	0.177	New land—rich
161	"	W. G. Schamberger, Gallatin	0.25	0.20	0.29	......	Subsoil to No. 160
567	Williamson	J. R. Buckner, Thomsons Station	0.32	0.20	0.33	0.07	Old land—poor
568	"	J. R. Buckner, Thomsons Station	0.97	0.18	0.59	0.03	Subsoil to No. 567

GENERAL CONCLUSIONS FROM THE ANALYSES

Phosphoric acid—The majority of the analyses show the presence of unusually large amounts of phosphoric acid, so that many of the soils would be called rich in this element. A few, however, Nos. 615, 616, 578, 617 and 635, are only moderately supplied, about on a par, in fact, with the Chickamauga limestone of East Tennessee.

Lime—The lime contents of these soils are as a rule good, but by no means sufficiently high to warrant the neglect of liming. Nos. 175, 176, 577 and 617 would be classed as rich in this element and only one, No. 578, is very poor.

Potash—The potash supplies are good on the average, but Nos. 561, 578, 615 and 616 rank only as medium, so that at least moderate applications of this element might be used to advantage in grain growing and the like, where the crops are sold off the farm.

Nitrogen—The nitrogen percentages are medium on the average uplands, and good on the bottom lands. The uplands have lost much of this element under cultivation, and its return to the soil should be a matter of concern. In fact it is decidedly the most important element of plant food needed by the average upland of this section.

No. 822 is an interesting example of a soil which when judged by actual production would be classed as "poor" for crops like corn or wheat, but "good" or even "rich" for clover. The low nitrogen content, due to long continued grain farming, would account for the small crops of the cereals but did not interfere with the growth of a legume like clover, the soil supply of the minerals being "good."

As is generally true throughout the State the bottom lands have a greater soil depth than the uplands so that the plant-food supplies are increased accordingly. The analyses of bottom lands can not therefore be strictly compared with those of uplands.

FERTILIZER EXPERIMENTS

The use of fertilizers on the field from which No. 572 was taken has demonstrated that increased yields of wheat follow applications of both phosphoric acid and nitrogen. Experiments made on soils containing the larger amounts of phosphoric acid, e. g., Nos. 42 and 633, have not thus far shown that this element is needed, but the long-cultivated uplands are practically always deficient in nitrogen.

WEST TENNESSEE

Over nearly all this section of the State the soils are derived from geological deposits which were not consolidated into rock. The lands lie better as a whole for cultivation and can be more completely put under the plow than elsewhere in the State. The majority of the soils are silt loams which are adapted not only to a great variety of general farm crops, including tobacco and cotton, but to trucking crops, and to the production of both large and small fruits. They are, however, not so durable as those of the Central Basin, and in this respect resemble many of the soils of East Tennessee. Over large areas they have become greatly impoverished by constant corn and cotton cropping, but can be quickly improved. Although the country is only gently undulating, the soil is of such a silty nature that it washes away easily and to a ruinous extent, unless carefully protected.

Along the Mississippi River are very rich alluvial lands, surpassing in durability and productiveness any others in the State. No analyses, however, have been made of them.

Tile drainage is often needed and in at least one county, Obion, it has been found necessary and highly profitable over large areas.

TABLE XIX—*Chemical analyses of West Tennessee soils*

Lab. No.	County	Farm of	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
662	Carroll	John Mell	0.08	0.17	0.22	0.101	Old land—good
661	"	" "	0.05	0.11	0.33	0.048	Subsoil to No. 662
659	Chester	T. B. Carroll, Henderson	0.11	0.19	0.20	0.087	Old land—medium
664	Dyer	——, Dyersburg	0.09	0.17	0.25	0.059	" " —poor
158	Gibson	O. E. Chandler, Gibson	0.07	0.16	0.21	0.099	" " —medium
159	"	O. E. Chandler, Gibson	0.07	0.11	0.26	....	Subsoil to No. 158
668	"	John T. Hall, Humboldt	0.09	0.23	0.23	0.134	New land—good
670	Hardeman	R. A. McAnulty, Hickory Valley	0.09	0.23	0.35	0.090	Old land—medium
658	Henderson	E. S. Boswell, Lexington	0.08	0.17	0.24	0.091	" " —poor
663	Henry	————, Paris	0.08	0.15	0.23	0.072	" " "
749	Fayette	W. N. McFadden, Oakland	0.09	0.09	0.32	0.076	" " "
671	McNairy	————, Selmer	0.06	0.11	0.21	0.097	" " "
669	Obion	————, west of Obion	0.10	0.40	0.29	0.132	" " —rich
666	Weakley	Geo. Boyd, Dresden	0.08	0.21	0.24	0.120	Forest land—good
665	"	" " "	0.07	0.11	0.30	0.047	Subsoil to No. 666
667	"	" " "	0.09	0.16	0.28	0.093	Old land—good

GENERAL CONCLUSIONS FROM ANALYSES

Phosphoric acid—The phosphoric acid percentages of these soils are comparatively uniform, the highest being 0.11 per cent and the average about 0.08 per cent. They must be classed, therefore, as poor in this element, so that at least the phosphoric acid removed by the crops should be returned to the land.

Lime—Although these soils are not derived from limestone rock, the lime content is even superior to that from some of the limestone areas. They must, however, be looked upon as only moderately well supplied, so that liming would be expected to give beneficial results.

Nitrogen—The nitrogen percentages are medium for the virgin soils, but the worn lands have as a rule become decidedly impoverished, so that they must be classed as poor. Soil No. 669, from Obion County, is, on account of its superior depth, well supplied with this and the other important constituents.

FERTILIZER EXPERIMENTS

Fertilizer experiments made in this section warrant the use of phosphoric acid and nitrogen. Potash is much less required.

MISCELLANEOUS SOILS

TABLE XX—*Chemical analyses of miscellaneous soils*

Lab. No.	County	Locality	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)	Remarks — (quality based on average expectancy when unfertilized)
			P. ct.	P. ct.	P. ct.	P. ct.	
135	Blount	Top of Thunderhead Mt. (Thunderhead conglomerate)	0.24	0.24	0.76	0.582	Rich pasture—virgin soil
576	Giles	Near Pulaski (phosphate)	1.52	1.38	0.34	0.100	Old land
584	"	Near Pulaski (phosphate)	1.70	2.25	0.42	0.146	" " river bottom —rich
594	Roane	Near Harriman (Rome sandstone)	0.04	0.09	0.09	0.074	Sandy, pine land—very poor

REMARKS ON THE ANALYSES

No. 135 is a sandy loam, long used as a pasture, on the top of Thunderhead Mountain, at an elevation of about 5,400 feet and near the line between North Carolina and Tennessee. It has the reputation of being very fertile. It is the richest in nitrogen of all the soils that we have examined, and is well supplied with the other elements of plant food.

No. 584 is a very fertile bottom land near Pulaski, Giles County. This land is said to have been cropped for fifty years with little return of the fertility removed, and to give at the present time scarcely diminished yields. The phosphoric acid supply is very unusual and the nitrogen and potash contents are good. The composition suggests that it was derived from the disintegration of phosphate rock, and is also of interest as showing that the phosphoric acid is largely combined with lime, no soil in the State, of other origin, having been found to contain anything like so large an amount.

No. 576 is an upland derived from rock phosphate, and has a similar composition to No. 584, except that the nitrogen content is low. Of course such soils would not be expected to require attention so far as phosphoric acid and lime for plant-food purposes are concerned, but under cropping, without return of plant food removed, would, as in this instance, become poor in nitrogen, and later in potash as well.

No. 594 is a poor, sandy soil from the Rome formation in East Tennessee. Pines were the common forest growth. The newly cleared land is suited to strawberries and the like, but should be fertilized to give the best results.

COMPLETE ANALYSES

In Table XXII are the analyses of the "insoluble" residues left after digestion in strong hydrochloric acid in the usual soil analysis.

Table XXI gives for the most important elements the sums of both analyses, or the total amounts in the original samples.

TABLE XXI—*Total amounts of important plant-food constituents*

Lab. No.	Section and formation	County	Phosphoric acid (P_2O_5)	Lime (CaO)	Potash (K_2O)	Nitrogen (N)
			P. ct.	P. ct.	P. ct.	P. ct.
	East Tennessee Valley					
58	Knox dolomite—ridge	Hamblen	0.069	0.115	0.611	0.112
636	" " —valley	Knox	0.176	0.178	1.030	0.128
57	Chickamauga limestone	Hamblen	0.084	0.192	0.679	0.097
49	Maryville limestone	"	0.116	0.146	0.604	0.079
614	Alluvial	Knox	0.210	0.691	2.058	0.131
	Cumberland Plateau					
67	Walden sandstone	Cumberland	0.043	0.073	0.472	0.085
	Highland Rim					
583	Limestone	Stewart	0.075	0.236	1.480	0.105
	Central Basin					
572	Limestone	Bedford	0.150	0.274	1.076	0.130
633	"	Marshall	0.300	0.231	0.933	0.116
634	"	Sumner	0.245	0.302	1.273	....
	West Tennessee					
670		Hardeman	0.104	0.332	1.971	0.069
666		Weakley	0.100	0.343	1.767	0.120

GENERAL CONCLUSIONS FROM THE COMPLETE ANALYSES

The analyses of these insoluble residues show that the hydrochloric acid digestion removed in each case most of the phosphoric acid, lime, and magnesia, but that large amounts of potash were unacted upon. These results prove that some soils contain at most only small amounts of phosphoric acid and lime, and that to assume the contrary would lead to disastrous results, for by no method except the supplying of these elements from outside sources could enough in available forms be gotten to satisfy the continued demands made by even average crops. With potash, however, the case is somewhat different, as even the soils which are recognized as the poorest in the State are fairly well supplied with this element.

SOIL ACIDITY

The fact that clovers, cowpeas, Timothy, and orchard-grass, all of which are sensitive to a greater or less degree to soil acidity, are grown extensively throughout the State is a strong proof that the soils as a rule are not strongly acid. On the other hand, to find a soil which is not at least somewhat acid is the exception. Frequently the acidity is sufficient to be very injurious and to explain the failure to get, even when well manured, a satisfactory growth of clover, although, in the case of red clover, as has been demonstrated by Bain and Essary,* the prime cause of the failure "to keep the stand" can be attributed to a fungous disease which is to a great extent independent of soil conditions. The most desirable soil reaction for general farm and garden crops is neutral or slightly alkaline. Even a little acidity is harmful and makes liming a necessity in order to obtain the best results in crop production.

*Tenn. Bull. Vol. XIX, No. 1.

TABLE XXII—*Analyses of insoluble residues*

Lab. No.	Section and formation	County	Insoluble residue from original soil	Silica (SiO_2)	Potash (K_2O)	Soda (Na_2O)	Lime (CaO)	Magnesia (MgO)	Manganese oxide (MnO)	Ferric oxide (Fe_2O_3)	Alumina (Al_2O_3)	Phos. acid (P_2O_5)
	East Tenn. Valley		P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
58	Dolomite	Hamblen	90.33	95.65	0.54	0.15	0.038	0.038	None	1.68	1.87	0.035
636	"	Knox	82.49	94.81	0.84	0.32	0.060	0.072	Trace	1.08	2.77	0.047
57	Chickamauga limestone	Hamblen	87.04	97.39	0.36	0.14	0.019	0.039	None	0.97	1.07	0.016
49	Maryville limestone	"	85.64	95.98	0.42	0.14	0.026	0.086	"	1.46	1.85	0.038
614	Alluvial	Knox	82.71	88.94	2.00	0.80	0.360	0.224	Trace	1.41	6.18	0.086
	Cumberland Plateau											
67	Walden sandstone	Cumberland	91.25	96.83	0.43	0.18	0.027	0.062	None	0.70	1.76	0.016
	Highland Rim											
583	Limestone	Stewart	89.82	93.68	1.46	0.49	0.096	0.008	"	0.86	3.38	0.027
	Central Basin											
572	Limestone	Bedford	83.81	94.84	0.89	0.30	0.041	0.054	"	0.94	2.90	0.036
633	"	Marshall	86.14	95.13	0.79	0.23	0.060	0.077	"	1.08	2.59	0.044
634	"	Sumner	87.62	94.08	1.17	0.36	0.078	0.084	"	0.94	3.24	0.045
	West Tennessee											
670		Hardeman	88.09	91.66	1.84	0.76	0.118	0.125	"	0.81	4.68	0.013
666		Weakley	90.12	91.29	1.70	1.17	0.153	0.094	"	0.77	4.80	0.023

In Table XXIII are given the acidities of various soils as determined by the Veitch method,* which seems to the writer to give results more in harmony with the field tests than any other method now in use. The results are expressed in terms of the lime necessary to neutralize completely the acids in the soil. For example, if the average weight of an acre of soil to the depth of one foot be taken as 3,500,000 pounds, then an acidity of 0.1 per cent means that approximately 3,500 pounds of quicklime would be necessary to correct it.

TABLE XXIII—*Acidity of various soils*

Lab. No.	Section of State	County	Acidity in terms of lime (CaO)	Remarks
			P. ct.	
820	East Tennessee Valley....	Knox............	0.09	Dolomite soil at Station farm Alsike clover, even when heavily manured, makes only sickly growth without lime Red clover, alfalfa and cowpeas much benefited by liming
612	" " "	"	0.05	Alluvial soil. Alsike clover makes poor growth unless limed. Alfalfa helped by liming
812	" " "	"	0.08	"Crawfishy" soil
830	" " "	"	Neutral	New land — marble. Red clover very thrifty. Potatoes scab
746	Cumberland Plateau....	Cumberland......	0.12	Old pasture
866	" "	"	0.06	Forest soil
868	" "	"	0.08	Old field soil
565	Limestone of Rim.........	Franklin.........	0.05	Good corn and wheat land
569	" " "	Lawrence.........	Neutral	Virgin soil
581	" " "	Stewart...........	"	" "
867	The Barrens..............	Coffee...........	0.02	Old land—poor
589	" "	Dickson..........	0.05	" " "
843	" "	Putnam..........	0.06	" " "
844	" "	"	0.07	Virgin soil near No. 843
585	" "	Stewart..........	0.03	Virgin soil
806	" "	Warren..........	0.05	Old land—very poor. Clover not grown
747	Central Basin............	Bedford.........	0.04	Red clover makes good growth
633	" "	Marshall........	0.05	Good clover land
635	" "	Rutherford.......	Neutral	Red clover excellent
822	" "	Smith...........	0.03	" " "
634	" "	Sumner..........	0.04	Good clover land
668	West Tennessee........	Gibson..........	0.04	New land
839	" "	Madison........	0.07	Bottom land
669	" "	Obion...........	0.04	Good red clover land

The results indicate general soil acidity throughout the State, and the strong probability is that where clover has been considered to make satisfactory yields in spite of a somewhat acid soil a profitable increase would result from liming.

*Jour. Am. Chem. Socy., 1904, 26, 661.

SUGGESTIONS FOR TENNESSEE SOILS

HUMUS

One of the soil constituents which is well known to decrease under usual cultivation is humus, as the dark-colored organic substances which result from the decay of vegetable matter, etc., are called. The value of vegetable matter in the soil can hardly be overestimated. Especially is this true in the South, where the climatic conditions through a large part of the year are favorable to oxidation and consequent loss of humus from the soil. In addition, the prevailing soil texture, and the hilly and rolling nature of the country, are such that except on well-set grass land there is a continual loss of the best of the soil by washing. This loss of surface soil may have something to do with the maintenance of the mineral plant-food supplies, which are, to a certain extent, renewed in this way; but, on the other hand, it takes away the humus and its chief plant-food constituent, nitrogen, both of which are found in only meager quantities in the subsoil. Furthermore, with this loss of humus there is a decided deterioration in the structure, or tilth, of the soil, which dries out sooner, bakes worse, and is more troublesome to handle than when first cultivated. For these reasons particular attention should be given to the building up of the soil by the incorporation of vegetable matter, and to its retention by deep plowing to prevent washing, by the growing of cover crops, and in some cases by the use of embankments and the like. The disfavor with which many farmers look upon commercial fertilizers comes as a result of relying too much on small applications of the mineral elements without either making adequate applications of farmyard manure or following a system of cropping which would in and of itself do much toward the maintenance of soil fertility, especially with respect to the supplies of both vegetable matter and nitrogen.

CROP ROTATIONS

The systematic changing of the crops grown on the same land not only permits of the most economical use of farm labor and lessens the injury done by insect pests and fungous diseases, but also has much to do with the productiveness of the soil. The best rotations agree in certain essentials, such as the necessity of a leguminous, or nitrogen-gathering, crop, like clover, the importance of a cultivated crop to clean the land of certain weeds, and the value of a crop like grass, which leaves a large residue of roots and stubble and improves the structure of the soil. Throughout the State a well-founded crop rotation should be considered the first essential in soil improvement. In some instances, for example take the average Central Basin soil, a judicious rotation of crops, which should be in large part fed on the farm, and the manure carefully returned, together with careful tillage, is all that is necessary in order to get yields which will compare favorably with those produced in the early years of its cultivation. Over other areas, which are very large in the aggregate, commercial fertilizers can be profitably used, as an aid to hasten the success of the rotation. On a third class of soils, not only crop rotation and careful tillage, but also commercial fertilizers should be looked upon as necessities.

The following rotations have been thoroughly tested in practical experience and are recommended as founded on correct principles. Each rotation is of course adapted to certain conditions dependent not only on the kind of farming but also in some instances on the kind of soil and the inclinations and the experience of the farmer:

CROP ROTATIONS FOR TENNESSEE

1. GENERAL FARMING—FIVE-YEAR ROTATION

Corn, followed by rye for pasture and green manure
Soy beans, or cowpeas
Wheat, or other small grain
Clover and grass
Clover and grass

This is an admirable rotation for general farm purposes under the usual conditions found in this State.

2. GENERAL FARMING—THREE-YEAR ROTATION

Corn alone or with cowpeas (manured)
Wheat (fertilized)
Clover and grass

This is a common rotation which is practiced in Tennessee and other states, and which could be advantageously used here more extensively than it is at present.

3. POTATOES AND GENERAL FARMING—FOUR-YEAR ROTATION

Corn and cowpeas, pastured off
Wheat
Clover
Potatoes (fertilized), corn (same year as potatoes)

This rotation has been successfully practiced by W. G. Wilkinson, of Cornersville, Marshall County. His soil is of the fertile Central Basin type and is naturally well suited to the crops grown.

4. DAIRY FARMING, ETC.—FOUR TO FIVE-YEAR ROTATION

Corn and cowpeas (manured), followed by rye and crimson clover
Sorghum and cowpeas (fertilized)
Wheat (fertilized)
Clover and grass

This is the dairy farm rotation, practiced by S. R. Ogden near Knoxville. Mr. Ogden has demonstrated that the naturally poor Knox dolomite ridge soils can be profitably built up by good methods of farming, which include moderate applications of acid phosphate and potash salts.

5. COTTON PLANTERS—THREE-YEAR ROTATION

Cotton (fertilized), crimson clover
Corn and cowpeas (manured)
Oats
Cowpeas (same year as oats)

This is a cotton planter's rotation used in various sections of the South.

6. TOBACCO GROWERS—FOUR TO FIVE-YEAR ROTATION

Tobacco (fertilized)
Wheat (fertilized)
Clover and grass

This is a well-known tobacco grower's rotation, the tobacco taking the place of corn in rotation 2.

7. PASTURE FOR HOGS—TWO-YEAR ROTATION

Corn and cowpeas (allowed to mature)
Rye (sown first of November)
Clover (alsike, sown last of February)

This rotation has been successfully practiced for about twenty years by the Conger Brothers, Fayetteville, Lincoln County, on rich hilltops which are not easily accessible.

8. GREEN MANURE AND GRAIN—THREE-YEAR ROTATION

Cowpeas or soy beans
Wheat
Crimson clover (sown in July)

Highly recommended for soils adapted to crimson clover.

9. GREEN MANURE AND POTATOES—ONE-YEAR ROTATION

Crimson clover (sown last of August)
Potatoes (fertilized)

This is another green-manure rotation. As in No. 8, both crops are grown each year. It has been especially recommended by Mr. R. W. Powell, of Westel, as suited to the Cumberland Plateau. It is also known to have been successfully practiced in other parts of the country.

10. PASTURE FOR HOGS—TWO-YEAR ROTATION

Red or alsike clover and oats (sown in late summer or early spring)
Sorghum
Barley (sown last of August)
Soy beans or cowpeas (allowe[illegible]pen)

This is a pasture rotation used for [illegible]t the Station farm.

A general farm rotation extendi[illegible] a period of five or more years is very advisable rather than a short rotation, which should be considered only as a temporary expedient.

SPECIAL FERTILIZER RECOMMENDATIONS

For convenience in making somewhat definite recommendations the various types are placed, according to their requirements, into four groups, which are arranged in order, beginning with those uplands which are naturally the poorest in plant food.

Group I. (1) The Barrens of the Highland Rim, (2) the Cumberland Plateau, (3) the Knox dolomite ridges, and (4) other areas of similar plant-food contents.

These soils are naturally the least productive in the State, not because as a rule they are poorly drained, or because the physical condition is bad—for it is generally good—but because they are by nature insufficiently supplied with plant food, especially in the mineral elements, phosphoric acid, lime and potash.

Farming of any kind, grazing of stock over wide ranges excepted, should not be undertaken without the aid of fertilizers, which should be used for many years in sufficient quantities to furnish more phosphoric acid than the amount required by the crops, at least enough potash so that the amount removed by the crops can be returned to the land, and at least enough lime to keep the soil from having an acid reaction.

Taking everything into consideration, so far as the writer is able, the following recommendations are made in regard to the kinds and amounts of mineral fertilizers, etc., which may be used yearly, except where otherwise specified, in order profitably to build up these soils when properly cropped and tilled, including the saving and return to the land of all the manure possible:

TABLE XXIV—*Special fertilizer recommendations for the Barrens, etc.*

Element	Material advised	Amount per acre	Remarks
		lbs.	
Phosphoric acid	1. Acid phosphate	300	Highest in immediate availability
	or 2. Steamed bone meal	200	Slower in action than acid phosphate, but gives excellent results on soils poor in lime
	or 3. Thomas slag meal, or odorless phosphate	300	More available than the steamed bone meal. Very valuable on acid soils and those poor in lime
	or 4. Ground phosphate rock (floats)	1000—once in four years	This material is recommended only to a limited extent for acid soils
Potash	1. Muriate of potash	60	Cheapest of the German potash salts, but others can be substituted for special purposes
	or 2. Wood ashes	600	Contains much lime and is an especially good source for tobacco
Lime	1. Quicklime	2000	To be applied once in 4 or 5 years according to the rotation
	or 2. Ground limestone	4000	To be applied as the above

Fertilizers valuable only for nitrogen would not be expected to give the best results on any of these soils unless used in conjunction with the minerals, of which those containing phosphoric acid are of foremost importance in this connection. For this reason, and also because it is generally convenient to apply the various elements in mixtures, the following formulas are given:

FERTILIZER FORMULAS

1. CORN, SORGHUM, ETC.

300 lbs. acid phosphate
50 lbs. muriate of potash
200 lbs. cotton-seed meal

Instead of the cotton-seed meal a top-dressing of 90 pounds of nitrate of soda may be made as soon as the corn is up.

2. POTATOES, TOMATOES, ETC.

300 lbs. acid phosphate
80 lbs. muriate of potash
400 lbs. cotton-seed meal

Instead of the cotton-seed meal, a top-dressing of 150 pounds of nitrate of soda may be used as soon as the plants are up, or shortly after transplanting, as the case may be. 1,000 or even 1,500 pounds of the mixture to the acre may sometimes be used to advantage.

3. COWPEAS, SOY BEANS, CLOVER, ETC.

300 lbs. acid phosphate
50 lbs. muriate of potash

4. WHEAT AND OTHER WINTER GRAINS, FOLLOWED BY CLOVER

300 lbs. acid phosphate
50 lbs. muriate of potash

In March, when spring growth starts, sow broadcast 50 to 75 pounds of nitrate of soda to the acre.

5. TOBACCO

300 ibs. acid phosphate
120 lbs. sulphate of potash (the carbonate is best, and is the kind found in wood ashes)
400 lbs. cotton-seed meal

6. COTTON

300 lbs. acid phosphate
50 lbs. muriate of potash
400 lbs. cotton-seed meal

Except where liming has been practiced ammonium sulphate is not advised for these soils, whose acid tendencies would be increased by its use.

Nitrate of soda, on the other hand, corrects acidity by leaving alkaline residues. It is very valuable as a top-dressing for grass, etc., in the spring, but the cotton-seed meal has been found to give even better results for potatoes and trucking crops when used in the mixtures, and at present is more easily obtained than the nitrate.

Group II. (1) The majority of the West Tennessee uplands, (2) the limestone of the Highland Rim, (3) the Chickamauga limestone, the shales, and the Knox dolomtie valley type of East Tennessee, and (4) other soils of similar phosphoric acid contents.

These soils are naturally more in need of phosphoric acid than of any other mineral element, so that, under judicious management, aided by this element applied in an available form, they may, even when badly run down, be brought to a high state of productiveness. Without the aid of phosphates it is difficult to maintain high fertility in general or mixed farming and under exclusive grain farming the productiveness is soon brought to a low ebb. Therefore at least enough phosphoric acid to replace that sold off the farm, say, the equivalent under usual conditions of 200 pounds per acre of acid phosphate, should be considered necessary.

Less potash is required than for the soils of Group I, so that in stock farming where the manure is carefully utilized it requires little attention. In other kinds of farming moderate applications are advisable, except in the few instances where the soils are "rich."

The same fertilizer formulas as for Group I are recommendeo, with the excetpion that the potash salts may be reduced by one-half.

Lime may be applied about as in Group I, and at least enough to correct soil acidity is strongly advised.

Group III. Various soils from different parts of the State with a phosphoric acid content between 0.1 and 0.2 per cent.

Soils of this class require less attention to phosphoric acid than those of Group II, so that stock and general farming may be carried on with highly satisfactory results without the aid of phosphates. Even these soils, however, feel the loss of phosphoric acid under continued grain farming, in which case the moderate use of both phosphoric acid and potash is highly advisable. A mixture of 200 pounds of acid phosphate and 50 pounds of muriate of potash could well be used for a green manure crop or directly for wheat which is to be followed with clover. Dressings of 50 to 75 pounds of nitrate of soda per acre may be used to advantage for grass, wheat, etc. For trucking crops the formulas in Group I may be used, the amounts per acre being governed by the usual conditions.

Light dressings of lime are especially advisable where there is soil acidity, and the suggestions under Group I may be followed.

Group IV. Soils of the Central Basin type, which contain large amounts of phosphoric acid, frequently in the neighborhood of 0.3 per cent.

Such soils require no attention to phosphatic fertilizing in either general stock or grain farming. Moderate applications of potash salts would, however, be advisable about as for Groups II and III. Light dressings of lime are recommended, which, as for the other groups, should be at least sufficient to neutralize any soil acidity. The equivalent of one ton of quicklime per acre once in five or six years would probably be ample.

The most important plant-food element for this group is nitrogen, which is most economically brought to the soil through bacteria under the following conditions:

1. The pasturing of land in clover and grass.

2. The growing of leguminous crops, such as clover, cowpeas, vetch, etc., which may (1) be fed, and the manure carefully saved and returned, or (2) be used for green manure, or (3) be grazed off.

Clovers and alfalfa by leaving large residues in the soil undoubtedly add greatly to the supply of available nitrogen for the succeeding crop, but cowpeas and the like when removed leave comparatively little. These remarks on nitrogen apply, of course, with equal force to the soils of all four groups.

Nitrate of soda may be used as in Group III. For rapid growing garden or trucking crops the following formula is recommended for this class of soils:

200 lbs. acid phosphate
400 lbs. cotton-seed meal
50 lbs. muriate of potash

From 500 to 1,500 pounds of the mitxure would be practical amounts per acre.

GEOLOGICAL ORIGIN THE BEST BASIS OF CLASSIFICATION FOR TENNESSEE SOILS

Soil texture and structure, or the physical nature of the soil, is the basis of classification often followed. As a result, however, of a careful study both of the soils and of the agricultural conditions of this State, the basis of classification first chosen by the Station was geological origin, and this affords, from the writer's point of view, decidedly the best means of grouping these soils with regard both to physical and to chemical composition. This bulletin demonstrates the uniformity of the plant-food supplies, and undoubtedly there is much similarity in the physical properties of the soils derived from the same formation. Furthermore, there is comparatively little mixing of the uplands of different origin, the line of demarkation generally being very sharp.

To base the classification on texture and structure alone would be to ignore the exceedingly important factor of plant-food supply, on which would depend not only the use of fertilizers but also to a great extent adaptability to kind of farming. The crops and rotations suited to a soil rich in plant food may not be suited to a soil poor in plant food, although their texture may be as nearly alike as possible. The silt loams of the Central Basin are by nature well supplied with the mineral elements of plant food, so that clover thrives, and in turn assists in the production of grass, which is highly profitable. On the Rim the silt loams are poor in the mineral elements, and clover and grass do not thrive as in the Basin, so that other crops are used as profitable substitutes. Of course it must be granted that it is possible to add plant food, etc., to the poor soil until it will produce like that naturally richly supplied, but time and expense are necessary to bring about such a result. On the other hand, soils unlike in texture may on account of their plant-food contents be well suited to the same crops. The market gardeners use to advantage in the production of similar crops a great variety of soils, which are manured until they are suited to the purpose. There are without doubt special crops and special objects to be gained for which only certain soil textures are suitable; but are these not exceptions to the rule rather than the rule itself?

In support of the geological basis of classification attention should also be called to the well-known fact that "clay" is of different kinds and may have remarkably different properties, which are dependent on chemical composition. That is, "clay" may be true clay—the hydrated silicate of alumina—or may consist largely of finely sub-divided silica. Similarity in the composition of the "clay" from the same formtaion would be expected, while dissimilarity in the "clay" from different formations would occasion no surprise.

To illustrate the great difference in natural productiveness, which in the opinion of the writer can be attributed almost wholly to the differences in plant-food supply, there is given below a comparison of the most important plant-food constituents and the productiveness of two typical soils:

	No. 806 (Table XVI, Fort Payne chert)	No. 633 (Table XVII, Central Basin)
	P. ct.	P. ct.
Phosphoric acid (P_2O_5)	0.044	0.250
Lime (CaO)	0.095	0.180
Potash (K_2O)	0.144	0.250
Nitrogen (N)	0.078	0.116

Yields per acre, beginning with land as cleared from virgin forest growth and unaided by fertilizers:

No. 806

Yields of corn for first 4 to 5 crops, 20 to 25 bu. per acre. First crop of wheat (4th year), about 12 bu. Yield of wheat at end of 5 to 6 years, 5 to 6 bu. Land soon thereafter thrown for a time out of cultivation "to rest."

No. 633.

For first 12 to 15 years, yields of corn 50 to 75 bu., with gradual decrease thereafter to 35 to 40 bu. Soil at first too rich for best production of wheat. Average yield of wheat for last 20 of the 50 years under cultivation, 19¼ bu. per acre.

Remarks.—These two soils have not exactly the same texture, but both are easily handled and would probably come under the head of silt loams. Each soil showed an acidity of 0.05 per cent. By the aid of commercial fertilizers, the productiveness of No. 806 has been gradually increased until at this time much better crops are obtained than when first cultivated, and in an adjoining field of similar character there have been gotten, under special manuring, yields of both wheat and corn which surpass those usually obtained on soil No. 633. No. 633 when reduced by continued grain production is quickly brought up by the growing of clover, pasturing, etc., without the aid of fertilizers.

In this connection emphasis should be laid on the fact that while these two examples are extremes, both in plant-food supplies and in natural productiveness, they are not isolated instances, but representative of large areas, and that between these extremes fall the majority of the soils of this State, both in plant-food contents and in productiveness, the two being strikingly related.

TABLE XXV—*Analyses of Tennessee soils*

Lab. No.	Section and formation	County	Insoluble residue	Potash (K_2O)	Lime (CaO)	Magnesia (MgO)	Manganese oxide (Mno)	Ferric oxide (Fe_2O_3)	Alumina (Al_2O_3)	Phosphoric acid (P_2O_5)	Sulphuric acid (SO_3)	Volatile matter	Humus	Nitrogen	Fine earth—Diam. less than 0.5 mm.	Remarks
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	
	East Tenn. Valley															
58	Knox. dolomite—ridge	Hamblen	90.33	0.121	0.081	0.130	..	0.97	2.60	0 037	0.019	5.24	0.97	0.112	82.50	Virgin soil
59	" " "	"	93.87	0.071	0.058	0.282	0.106	1.00	2.68	0.032	0.015	2.24	...	0.037	83.59	Subsoil to 58
55	" " "	"	91.33	0.103	0.104	0.127	..	0.94	2.55	0.038	0.031	5.08	0.96	0.109	69 36	Old land
606	" " "	Knox	90.95	0.087	0.120	0.220	0.100	1.00	0.53	0.032	0.024	5.43	1.29	0.135	65.70	Virgin soil
31	" " "	"	89.23	0.140	0.090	0.110	..	6.01*		0.030	...	4.23	0.75	0.079	80.05	Old land
102	" " "	"	88.87	0.210	0.060	0.260	...	2.49	5.04	0.017	...	3.06	...	00.44	86.24	Subsoil to 31
48	" " "	"	85.99	0.160	0.138	0.202	0.405	7.69*		0.054	..	4.86	0.92	0.102	92.90	Old land
64	Knox dolomite—valley	Hamblen	88.71	0.230	0.160	0.170	...	1.98	4.53	0.047	0.026	4.56	0.77	0.095	83.89	Old land
25	" " "	Knox	82.75	0.280	0.170	0.150	.	10.38*		0.093	0.033	5.49	0.76	0.111	92.30	Old land
172	" " "	McMinn	83.48	0.382	0.129	0.375	0.320	10.13*		0.060	0.029	4.41	0.67	0.079	87.08	Old land
173	" " "	"	80.31	0.430	0.120	0.630	0.340	12.50*		0.046	..	4.88	..	0.051	93.44	Subsoil to 172
60	Shale	Hamblen	79.89	0.280	0.044	0.137	0.147	3.22	6.02	0.106	0.059	9.25	1.70	0.208	85.16	Old land
66	"	"	93.40	0.080	0.096	0.110	0.070	1.43	2.30	0.018	...	2.52	0.66	0.072	92.98	Old land
32	"	Knox	87.86	0.290	0.110	0.100	..	7.10*		0.092	0.029	4.21	0.85	0.090	94.54	Old land
602	"	"	...	0.265	0.120	0.220	0.128	3.48	5.13	0.088	0.021	5.82	1.09	0.100	96.69	New land
608	"	"	93.26	0.090	0.080	0.155	0.030	1.19	0.70	0.031	0.019	3.07	0.59	...	97.95	Virgin soil "crawfishy"
51	Chickamauga limestone	Hamblen	75.92	0.855	0.821	0.428	.	4.60	5.82	0.102	...	10.98	2.42	0.308	97.91	Virgin soil
57	" "	"	87.04	0.366	0.175	0.254	0.330	2.98	4.64	0.071	...	4.62	0.90	0.097	96.19	Old land
29	" "	Knox	86.11	0.430	0.220	0.240	...	2.05	5.60	0.077	...	5.20	1.18	0.120	99.48	Low land near creek, old
821	" "	"	87.07	0.266	0.100	0.307	0.174	2.48	4.92	0.090	0.026	4.46	0.96	0.094	80.72	Old land
174	" "	McMinn	82.42	0.680	0.310	0.530	0.370	8.32*		0.072	0.031	7.03	1.74	0.183	83.70	Virgin soil

*Ferric oxide and alumina combined.

TABLE XXV—*Analyses of Tennessee soils—Continued*

Lab. No.	Section and formation	County	Insoluble residue	Potash (K_2O)	Lime (CaO)	Magnesia (MgO)	Manganese oxide (MnO)	Ferric oxide (Fe_2O_3)	Alumina (Al_2O_3)	Phosphoric acid (P_2O_5)	Sulphuric acid (SO_3)	Volatile matter	Humus	Nitrogen	Fine earth—Diam. less than 0.5 mm.	Remarks
			P.ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	
595	Chickamauga limestone .	Roane	89.01	0.180	0.060	0.120	0.060	1.90	4.29	0.071	0 032	4.18	0.83	0.087	99.87	Old land
597	" " .	Washington . .	79.85	0.180	0.100	0.180	0.080	2.82	5.41	0.073	0.039	4.81	0.80	0.100	95.32	Old land
129	" " .	Anderson	89.05	0.210	0.120	0.190	0.230	1.82	4.00	0.170	....	4.46	1.12	0.123	96 34	Old land
49	Maryville limestone	Hamblen ...	85.64	0.244	0.124	0.245	0.291	3.12	6.05	0.083	...	4.46	0.66	0.079	97.43	Old land
600	Marble in Sevier shale . .	Knox	75.28	0.360	0.300	0.290	1.240	4.63	8.99	0.160	0.030	7.99	1.38	0.140	98.23	New land
603	" " " . .	"	74.79	0.417	0.382	0.738	0.491	5.89	7.04	0.187	0.060	9.08	...	0.190	97.31	New land
30	Holston marble	"	79.77	0.340	0.200	0.350	...	12.43*		0.099	..	6.02	...	0.100	91.93	Old land
37	Tellico sandstone	"	86.12	0.184	0.186	0.310		4.85	3.62	0.167	....	4.40	0.96	0.106	99.01	New land
553	" "	"	83.56	0.180	0.160	0.225	0.520	3.20	5.38	0.110		5.27	1.26	0.120	97.89	Old land
593	" "	Roane	79.19	0.300	0.260	0.330	0.410	3.16	7.97	0.095	0.054	8.11	1.17	0.152	96.58	New land
35	Alluvial soils	Blount	83.76	0.527	0.176	0.560	0.265	3.47	5.63	0.180	...		1.18	0.131	99.72	Old land
53	" "	Hamblen	75.83	0.910	0.730	0.960	0.030	12.35*		0.094	....	8.74	1.77	0.121	99.77	Old land
26	" "	Knox	83.75	0.450	0.430	0.480		9.73*		0.120	0.053	6.04	1.49	0.145	92.70	Old land
612	" "	"	83.13	0.415	0.415	0.527	0.152	4.03	5.50	0.093	0.057	5.69	1.34	0.131	94.86	Old land
	Cumberland Plateau															
605	Walden sandstone	Cumberland .	83.91	0.066	0.100	0.102	0.060	0.95	2.23	0.031	0.040	9.98	3.00	0.279	99.57	Creek bottom
746	" "	" . .	83.94	0.188	0.069	0.270	0.063	2.49	5.40	0.061	0.042	7.38	1.50	0.162	99.39	Virgin soil—extra good
67	" "	" . .	91.26	0.080	0.049	0.140	0.020	4.45*		0.028	0.018	4.43	0.70	0.085	97.73	Forest second growth
68	" "	" . .	91.95	0.060	0.049	0.163	0.010	5.14*		0.030	0.036	3.39	...	0.069	99.02	Subsoil to 67

*Ferric oxide and alumnia combined.

TABLE XXV—*Analyses of Tennessee soils—Continued*

Lab. No.	Section and formation	County	Insoluble residue	Potash (K_2O)	Lime (CaO)	Magnesia (MgO)	Manganese oxide (MnO)	Ferric oxide (Fe_2O_3)	Alumina (Al_2O_3)	Phosphoric acid (P_2O_5)	Sulphuric acid (SO_3)	Volatile matter	Humus	Nitrogen	Fine earth—Diam. less than 0.5 mm.	Remarks
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	
	Limestone of Rim (Bangor, Newman, etc.)															
750	....	Coffee	85.67	0.231	0.238	0.218	0.148	2.58	5.58	0.070	0.028	4.64	0.90	0.115	96.61	Old land
39	....	Franklin	83.74	0.314	0.213	0.300	0.380	2.91	7.20	0.091	0.053	5.54	1.06	0.125	99.62	Old land
565	....	" ...	83.00	0.270	0.160	0.230	0.390	2.73	7.24	0.100	0.022	5.64	1.09	0.120	98.92	Old land
566	....	"	81.88	0.340	0.140	0.270	0.100	4.26	8.01	0.045	0.028	4.34	...	0.043	99.58	Subsoil to 565
592	....	Humphreys ..	86.40	0.230	0.130	0.260	0.160	2.24	5.19	0.057	....	5.16	0.86	0.120	99.61	Old land
569	....	Lawrence	85.23	0.160	0.080	0.210	0.110	2.97	5.57	0.081	0.023	5.56	0.84	0.102	95.62	Virgin soil
570	....	"	80.03	0.280	0.080	0.310	0.030	4.44	10.67	0.060	....	5.20	...	0.060	97.88	Subsoil to 569
742	....	Montgomery .	89.58	0.221	0.145	0.236	0.057	2.25	4.03	0.054	0.044	3.22	...	0.074	98.05	Old land
581	....	Stewart	89.64	0.150	0.120	0.180	0.140	1.73	3.39	0.057	0.027	4.45	1.00	0.115	99.13	Virgin soil
583	....	"	89.82	0.170	0.150	0.180	0.100	1.72	3.33	0.510	0.025	4.53	0.84	0.105	99.18	Virgin soil
571	....	White	88.60	0.200	0.140	0.160	0.190	2.23	4.67	0.061	0.020	3.90	0.65	0.085	96.40	Old land
574	....	"	89.10	0.220	0.130	0.490	0.220	2.61	2.70	0.070	0.023	4.20	0.81	0.080	91.37	Old land
563	....	"	87.02	0.210	0.090	0.280	0.140	2.64	5.15	0.074	0.025	4.77	0.79	0.090	99.27	Old land
564	....	"	83.09	0.320	0.140	0.340	0.070	4.05	7.47	0.050	0.020	4.61	...	0.057	99.37	Subsoil to 563
	The Barrens of Rim (Tullahoma Form., etc.)															
867	....	Coffee	90.51	0.091	0.147	0.154	0.031	1.80	3.56	0.041	0.018	3.67	...	0.077	....	Old land
591	....	Dickson	90.36	0.160	0.080	0.240	0.080	1.72	3.81	0.036	....	3.80	0.54	0.087	93.11	Virgin soil
589	....	"	90.58	0.100	0.100	0.150	0.050	1.61	2.89	0.031	0.032	4.27	0.70	0.090	89.08	Old land
590	....	"	83.26	0.310	0.020	0.490	0.010	4.23	7.53	0.028	...	4.26	...	0.048	97.34	Subsoil to 589
585	....	Houston	90.26	0.150	0.100	0.190	0.040	1.54	3.19	0.038	0.019	4.20	0.74	0.090	96.11	Virgin soil
586	....	"	91.07	0.120	0.046	0.240	0.030	2.29	3.38	0.030	....	2.72	0.27	0.042	....	Subsoil to 585
582	....	"	91.89	0.150	0.090	0.180	0.050	1.66	3.05	0.055	0.019	2.83	0.42	0.060	74.88	Old land

TABLE XXV—*Analyses of Tennessee soils—Continued*

Lab. No.	Section and formation	County	Insoluble residue	Potash (K_2O)	Lime (CaO)	Magnesia (MgO)	Manganese oxide (MnO)	Ferric oxide Fe_2O_3	Alumina Al_2O_3	Phosphoric acid (P_2O_5)	Sulphuric acid (SO_3)	Volatile matter	Humus	Nitrogen	Fine earth—Diam. less than 0.5 mm.	Remarks
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	
	The Barrens of Rim (Tullahoma Form., etc.)															
579	....	Houston	90.02	0.130	0.340	0.160	0.140	1.81	2.99	0.092	0.050	3.82	0.90	0.070	98.05	Bottom land, old
587	....	Lewis........	91.86	0.180	0.060	0.170	0.030	1.61	2.88	0.026	0.022	3.35	0.49	0.050	98.00	Old land
588	....	"	85.47	0.250	0.030	0.350	0.020	3.18	6.82	0.040	....	3.96	...	0.040	99.00	Subsoil to 587
843	....	Putnam	93.36	0.070	0.069	0.118	0.046	0.97	2.53	0.032	0.023	2.84	0.74	0.070	....	Old land
806	....	Warren	90.22	0.144	0.095	0.141	0.049	2.05	3.83	0.043	0.020	3.43	0.77	0.078	91.25	Old land
575	....	"	93.23	0.080	0.070	0.130	0.050	1.24	2.45	0.018	0.022	3.03	0.63	0.070	95.27	Old land
580	....	"	91.36	0.110	0.070	0.130	0.030	1.90	3.45	0.014	....	2.82	...	0.046	....	Subsoil to 575
	Central Basin limestone (Chickamauga, etc.)															
751	....	Bedford	88.48	0.285	0.096	0.372	0.088	2.65	3.50	0.149	0.033	4.06	1.07	0.122	69.51	Old land
615	....	"	90.64	0.173	0.280	0.193	0.112	1.39	2.77	0.088	0.063	4.18	0.99	0.112	....	Bottom land, old
616	....	"	90.98	0.152	0.258	0.212	0.057	1.38	2.85	0.081	0.063	4.11	1.01	0.117	....	Bottom land, old
572	....	"	83.81	0.330	0.240	0.330	0.370	3.68	5.68	0.120	0.027	5.65	1.24	0.130	92.28	Old land
573	....	"	76.30	0.490	0.310	0.420	0.160	6.47	9.49	0.052	0.034	6.06	...	0.040	92.58	Subsoil to 572
577	....	"	88.47	0.460	0.570	0.440	0.140	3.11	7.63	0.190	0.060	6.89	1.73	0.150	99.43	Bottom land, old
578	....	"	89.85	0.190	0.050	0.190	0.080	2.15	3.20	0.052	0.020	3.91	0.87	0.090	95.27	Old land
747	....	"	83.98	0.260	0.140	0.240	0.332	3.12	5.82	0.165	0.047	5.27	1.34	0.148	93.43	Old land
748	....	"	84.62	0.308	0.109	0.275	0.229	3.37	6.91	0.110	0.033	3.67	..	0.068	96.46	Subsoil to 747
170	....	"	85.29	0.320	0.200	0.320	0.100	8.37*		0.260	....	4.67	1.05	0.112	74.54	Old land
171	....	"	86.02	0.427	0.188	0.403	0.094	8.23*		0.176	....	3.66	...	0.077	78.46	Subsoil to 170
175	....	"	83.00	0.432	0.566	0.368	0.123	8.24*		0.146	....	7.11	1.87	0.212	93.25	Bottom land, old
176	....	"	82.88	0.430	0.610	0.340	0.080	8.40*		0.150	....	7.02	...	0.210	91.11	Subsoil to 175

*Ferric oxide and alumnia combined.

TABLE XXV—*Analyses of Tennessee soils—Continued*

Lab. No.	Section and formation	County	Insoluble residue	Potash (K_2O)	Lime (CaO)	Magnesia (MgO)	Manganese oxide (MnO)	Ferric oxide (Fe_2O_3)	Alumina (Al_2O_3)	Phosphoric acid (P_2O_5)	Sulphuric acid (SO_3)	Volatile matter	Humus	Nitrogen	Fine earth—Diam. less than 0.5 mm.	Remarks
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	
	Central Basin limestone (Chickamauga, etc.)															
617	....	Davidson	81.22	0.708	0.456	0.798	0.044	3.51	6.86	0.066	0.047	6.10	1.75	0.190	....	New land
42	....	Lincoln	80.73	0.449	0.317	0.530	0.227	11.30*		0.312	...	5.60	0.97	0.128	91.09	Old land
561	....	Marshall	88.09	0.190	0.200	0.300	0.150	2.45	4.00	0.320	0.060	4.27	0.92	0.102	94.13	Old land
633	....	"	86.14	0.253	0.179	0.286	0.160	2.52	5.18	0.262	0.041	4.71	0.97	0.116	95.81	Old land
660	....	"	85.63	0.332	0.272	0.355	0 054	3.28	4.54	0.273	0.028	3.35	...	0.065	..	Subsoil to 633
635	....	Rutherford ..	81.92	0.294	0.220	0.235	0.377	4.42	6.12	0.081	0.047	5.42	1.28	0.116	91.74	Old land
822	....	Smith	90.58	0.222	0.172	0.212	0.101	1.93	3.35	0.215	0.030	3.09	0.67	0.079	91.55	Old land
634	....	Sumner	87.62	0.243	0.234	0.260	0 135	2.26	4.56	0.206	0.038	4.15	..	0.107	....	Old land
160	....	" ...	83.98	0.330	0.380	0.280	0.190	2.64	5.27	0.260	0.120	6.19	1.56	0.177	94.55	New land
161	....	" ...	84.05	0.290	0.200	0.380	0.150	2.80	5.15	0.250	....	6.71	....	..	93.99	Subsoil to 160
567	....	Williamson ..	86.84	0.330	0.200	0.320	0.110	3.37	4.30	0.320	0.035	4.23	0.66	0.070	98.83	Old land
568	....	" ...	82.20	0.590	0.180	0.230	0.070	4.22	7.06	0.970	0.015	4.31	...	0.030	98.69	Subsoil to 567
	West Tennessee															
662	....	Carroll	90.47	0.219	0.167	0.216	0.143	1.88	2.75	0.079	0.027	3.77	1.00	0.101	99.95	Old land
661	....	" ...	87.03	0.329	0.107	0.414	0.041	3.27	5.18	0.052	0.033	3.03	0.26	0.048	99.92	Subsoil to 662
659	....	Chester	90.21	0.203	0.194	0.217	0.137	2.00	3.25	0.111	0.027	3.51	...	0.087	...	Old land
664	....	Dyer	91.73	0.245	0.167	0.253	0.109	1 88	2.87	0.088	0.029	2.42	0.38	0.059	99.97	Old land
158	....	Gibson	90.47	0.210	0.160	0.250	0.220	1.83	3.29	0.069	0.070	3.77	0.78	0.099	99.89	Old land
159	....	" ...	89.12	0.260	0.110	0.370	0.110	2.72	4.53	0.068	...	3.18	...	....	99.99	Subsoil to 158
668	....	" ...	89.45	0.231	0.230	0.231	0.168	1.75	2.96	0.085	0.041	4.69	1.20	0.134	99.92	New land
670	....	Hardeman ...	88.09	0.351	0.228	0.336	0.113	2.63	4.69	0.093	0.036	3.40	0.40	0.069	99.95	Old land
658	....	Henderson ...	89.11	0.235	0.165	0.214	0.153	1.89	4.05	0.079	0.035	3.53	0.80	0.091	99.93	Old land

TABLE XXV—*Analyses of Tennessee soils—Continued*

Lab. No.	Section and formation	County	Insoluble residue	Potash (K_2O)	Lime (CaO)	Magnesia (MgO)	Manganese oxide (MnO)	Ferric oxide (Fe_2O_3)	Alumina (Al_2O_3)	Phosphoric acid (P_2O_5)	Sulphuric acid (SO_3)	Volatile matter	Humus	Nitrogen	Fine earth—Diam. less than 0.5 mm.	Remarks
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	
	West Tennessee															
663	....	Henry	90.71	0.231	0.153	0.216	0.106	2.12	3.24	0.076	0.032	2.94	0.64	0.072	99.99	Old land
749	....	Fayette	87.03	0.319	0.091	0.430	0.122	3.12	5.05	0.090	0.023	3.72	0.61	0.076		Old land
671	....	McNairy	88.32	0.205	0.112	0.192	0.069	2.32	4.24	0.062	0.046	4.34	0.92	0.097	99.49	Old land
669	....	Obion	88.20	0.287	0.396	0.427	0.051	2.39	3.39	0.099	0.047	4.44	1.16	0.132	99.91	Old land
666	....	Weakley	90.12	0.237	0.205	0.248	0.150	1.95	2.86	0.079	0.034	3.89	0.85	0.120	99.93	Virgin soil
665	....	"	87.73	0.345	0.110	0.409	0.043	3.13	4.84	0.065	0.034	3.10	0.30	0.047	....	Subsoil to 666
667	....	"	89.09	0.284	0.164	0.261	0.168	2.13	3.93	0.087	0.042	3.61	0.83	0.093	99.96	Old land
	Miscellaneous															
135	Thunderhead conglomerate	Blount	69.89	0.760	0.240	0.520	0.230	4.74	6.67	0.240	0.220	15.58	4.95	0.582	89.81	Virgin soil
576	Phosphate	Giles	81.91	0.340	1.380	0.340	0.170	3.48	4.14	1.520	0.040	4.82	0.62	0.100	93.84	Old land
584	"	"	80.16	0.420	2.250	0.350	0.090	3.17	5.32	1.700	0.080	6.11	1.67	0.146	90.99	Bottom land, old
594	Rome sandstone	Roane	92.97	0.090	0.090	0.230	0.230	1.15	2.26	0.040	0.021	3.35	0.57	0.074	....	New land

(ADDENDA)

Lab. No.	Section and formation	County	Insoluble residue	Potash (K_2O)	Lime (CaO)	Magnesia (MgO)	Manganese oxide (MnO)	Ferric oxide (Fe_2O_3)	Alumina (Al_2O_3)	Phosphoric acid (P_2O_5)	Sulphuric acid (SO_3)	Volatile matter	Humus	Nitrogen	Fine earth—Diam. less than 0.5 mm.	Remarks
	Limestone of Rim															
883	Farm of W. F. Story....	White	86.20	.229	.130	.253	.293	2.21	5.92	.071	.024	4.31	0.73	.095	96.98	Old land, red
871	" E. P. Turnley.	Montgomery	90.57	.201	.157	.235	.069	1 96	3.97	.051	.025	3.34	0.75	.079	97.30	Old land, grey
874	" P. L. Harned	"	87.17	.381	.257	.380	.132	2.34	4.79	.168	.028	4.13	1.01	.098	...	Bottom land
	Limestone of Central Basin															
885	Farm of Brown Bros	Maury	81.29	.316	.297	.351	.387	3.87	6.28	.213	.058	6.56	1.55	.164	95.54	Old land, good
873	" W. A. J. Simpson	Sumner	82.64	.409	.436	.397	.387	3.08	6.06	.384	.062	5.75	1.73	.161	96 15	Old land, good